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PHOENIX AREA FLOOD STUDIES

OCTOBER 1972

REPORT ON THE FLOOD OF 22 JUNE 1972
IN
PHOENIX METROPOLITAN AREA

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REPORT ON FLOOD OF 22 JUNE 1972
IN PHOENIX METROPOLITAN AREA, ARIZONA

INTRODUCTION

1. AUTHORITY. This report is submitted under the authority of Public Law 99, 84th Congress, 1st session, and in accordance with Corps of Engineers Regulation ER 500-1-1 titled "Emergency Employment of Army and Other Resources – Natural Disaster Procedures."

2. SCOPE. This report describes the storm and flood in the Phoenix Metropolitan Area, Arizona, during the period 21-22 June 1972 and presents the resultant flood damage in the cities of Phoenix, Scottsdale, Tempe, and in the unincorporated area surrounding Paradise Valley. Hydrologic data collected during the storm and flood are presented; local conditions created by the flood are discussed; damages to various types of property are tabulated; and estimates of damages that would have been prevented by Corps of Engineers projects authorized but not yet constructed are presented. Flood damages considered in this report include physical damages, emergency costs, and business losses to public and private property as a result of inundation or erosion by floodwaters and flood-transported debris, but do not include damages caused by rainfall or wind.

GENERAL DESCRIPTION OF DISASTER AREA

3. DISASTER DECLARATION. Governor Jack R. Williams of Arizona declared a state of emergency on 27 June 1972. The President declared Maricopa, Pima, and Pinal Counties, Arizona, major disaster areas on 3 July 1972.

4. LOCATION. The flood-damaged cities of Phoenix, Scottsdale, Tempe, and Paradise Valley are in the south-central part of Arizona. (See pl. 1.) The flooded areas lie in the Gila River Basin, a drainage area of 58,200 square miles – 5,600 in New Mexico, 51,500 in Arizona, and 1,100 in Sonora, Mexico.

5. CLIMATE. The drainage area has an arid, subtropical climate, characterized by hot summers, mild winters, and infrequent rainfalls. Summer thunderstorms of high intensity, but short duration, account for most of the annual rainfall.

6. TOPOGRAPHY. Part of the drainage area is mountainous; the remainder is a rolling, desert plain. Mountains near the flood-damaged areas include the McDowell Mountains northeast of Scottsdale, the Phoenix Mountains north and northeast of Phoenix, and the Salt River Mountains southwest of Phoenix and Tempe. Elevations in the flooded area range from about 1,000 feet at the Salt River to about 3,000 feet in the mountains north of Phoenix.

7. VEGETATION. Natural vegetation in the area is sparse, with cactus, creosote bush, sagebrush, and paloverde being the dominant desert plants. Irrigation has resulted in the transformation of the desert plain to productive farmland and urban communities.

8. STREAMS. Indian Bend Wash, a tributary to the Salt River upstream from Phoenix, drains an area of 224 square miles. (See pl. 1.) A small part of the Gila River Basin, the Indian Bend Wash Basin is about 10 miles east and northeast of Phoenix. The basin is 26 miles long and about 15 miles wide. Numerous streams drain the south side of the Phoenix Mountains. The principal drainage courses include Dreamy Draw Wash, which drains an area of 1.62 square miles and Cudia City Wash, which drains an area of 2.16.

9. CANALS. The Arizona and Grand Canals, units of the Salt River Project, deliver irrigation water to lands on the north bank of the Salt River. (See pl. 1.)

STORMS AND FLOOD

10. METEOROLOGY. Heavy thunderstorms hit northeastern Phoenix on the evening of 21 June and the morning of 22 June 1972. These storms were part of a series of moderate to heavy early summer thunderstorms affecting Arizona, Nevada, and Utah during 20-23 June 1972. The cause of these disturbances was a deep flow of very moist, unstable tropical air that invaded the southwestern United States from the Gulf of California and the Pacific Ocean west of Baja California.

11. PRECIPITATION. The storms' rainfall occurred between 6 a.m. and 12 a.m. on 22 June in the northeast part of Phoenix, with the greatest intensities recorded during a 1.5 to 2-hour period. The maximum unofficial intensity reported was 5.25 inches during an estimated 2 hours in the vicinity of 24th Street and Camelback Road in Phoenix. Amounts of 4.87 inches at 24th Street and Indianola Avenue and 4.45 inches at 3430 East Coolidge Street were reported by unofficial stations of the National Weather Service. The maximum recording-gage intensity measured was 3.85 inches in 1 hour and 20 minutes at 18th Street and Turney Avenue.

12. The intense part of the thunderstorm affected a rather small area, as indicated by the areas inclosed within the various isohyets shown on pl. 2. The tabulation below summarizes the depth-area relationship for the 6-hour duration of the storm.

Isohyet	Area
5 inch	1.37 sq. mi.
4.5 inch	7.78 sq. mi.
4 inch	17.93 sq. mi.
3.5 inch	36.61 sq. mi.
3 inch	51.13 sq. mi.
2.5 inch	68.30 sq. mi.
2 inch	93.39 sq. mi.
1.5 inch	162.64 sq. mi.
1 inch	258.84 sq. mi.
0.5 inch	310.61 sq. mi.

Rainfall readings for various official and unofficial gages are shown in table 1, and the gage locations are shown on pl. 3. Mass rainfall readings for four recording gages are shown on pl. 4.

13. RUNOFF. The heavy precipitation that occurred during the period 21-22 June 1972 caused relatively high discharges on the small drainage areas on the south slopes of the Phoenix Mountains and a record discharge on Indian Bend Wash.

14. A U.S. Geological Survey recording stream gage on Indian Bend Wash at Indian Bend Road indicated a peak discharge at this location of 17,000 cubic feet per second (c.f.s.). The flood hydrograph at this gage is shown on pl. 5, and the location of the gage is shown on pl. 3. In addition, 3,000 c.f.s. that was not measured by the stream gage flowed across Indian Bend Road. This would constitute a peak discharge of 20,000 c.f.s. at Indian Bend Road. This flood is estimated to have a frequency of occurrance of once every 70 years.

15. The USGS also made several slope-area measurements from high-water marks at various locations shown on pl. 2. The peak discharge at each of these points is listed in table 2. A comparison of peak discharges per square mile for recorded major floods in the Phoenix area with those of the 22 June 1972 flood is shown in table 3. An enveloping curve for these peak discharges is shown on pl. 6.

16. OVERFLOW AREA. Flooding occurred along Indian Bend Wash in Paradise Valley and in the unincorporated area surrounding Paradise Valley, Scottsdale, and Tempe. Other parts of the Paradise Valley area was subjected to sheet flow. Flooding occurred along the upstream sides of the Arizona Canal in Scottsdale and Phoenix and the Grand Canal in Phoenix. Flooding occurred below both canals in Phoenix due to spills and overtopping of the canals. A schematic drawing of the flooded area is shown on pl. 1.

TABLE 1

PRECIPITATION DATA, STORM OF JUNE 21-22, 1972
PHOENIX, SCOTTSDALE AND PARADISE VALLEY AREAS, ARIZONA

Gage No.	Name	Gage Location or Name of station	PRECIPITATION June 21 Amount	June 21 Period	June 22 Amount	June 22 Period	Storm Total (in)	Footnote references
1	Lew Carrifee	4936 W. Verde Ln.	.16	–	.28	–	.44	(1),(7)
2	Robert Ingram	63rd St. & Earll	.31	–	.53	–	.84	(1)
3	Ray Kistler	36th St. & Pickadilly	.44	–	3.31	–	3.75	(1)
4	Louis R. Jurwitz	25th St. & Bellview	.54	–	3.05	–	3.59	(1)
5	Melvin Ruth	9832 N. 7th Place	0	–	–	–	1.60	(1)
6	Goldsmith	28th St. & Highland	.41	–	4.23	–	4.64	(1)
7	Bill Erichson	4511 N. 31st. St.	.35	–	4.15	–	4.50	(1)
8	A.B. Clark	741 E. Ocotillo	.06	–	2.65	–	2.71	(1)
9	Frank Peddie	67th St. & Horseshoe Ln.	1.66	–	–	–	–	(1)
10	USGS	1648 E. Meadowbrook	–	–	–	–	4.20	(1)
11	Paul C. Kangieser	9020 S. 17th Place	0	–	.33	–	.33	(1),(7)
12	Ted Wilson	42nd St. & Indian School	.30	–	3.10	–	3.40	(1)
13	Bruce A. Cain	18th St. & Turney	.43	1 hr.	3.85	1 hr. 20 min.	4.28	(1),(8)
14	Salt River Project	McClintock & Southern	.06	–	.03	–	.09	(1),(7)
15	Do.	2200 E. McDowell	.31	–	2.84	–	3.15	(1)
16	Do.	39th Ave & Dunlap	.05	–	.10	–	.15	(1)
17	Do.	20th St. & Oak	.24	–	3.66	–	3.90	(1)
18	Do.	11th Ave & Culver	.04	–	3.10	–	3.14	(1)
19	Do.	Country Club & Southern	.43	–	.15	–	.58	(1)
20	Do.	Lawrence Ln. & 13th St.	Trace	–	2.19	–	2.19	(1)
21	Do.	7th St. & Roosevelt	.20	–	3.25	–	3.45	(1)
22	Do.	Mesa Dr. & Ramble Rd.	.43	–	Trace	–	.43	(1)
23	Do.	56th St. & Southern	.36	–	.08	–	.44	(1)
24	Do.	87th St. & Oak	.11	–	.34	–	.45	(1)

TABLE 1 (continued)

PRECIPITATION

Gage No.	Name	Gage Location or Name of station	June 21 Amount	June 21 Period	June 22 Amount	June 22 Period	Storm Total (in)	Footnote references
25	Do.	Stapley & Brown	.25	—	.34	—	.59	(1)
26	Do.	17th St. & Farmers	.08	—	.09	—	.17	(1)
27	Do.	Indian Wash & Ariz Canal	.90	—	1.36	—	2.26	(1)
28	Do.	38th Dr. & Puget	.07	—	.08	—	15	(1)
29	John Pritchard	42nd St. & McDonald	.55	—	3.87	—	4.42	(1)
30	Mr. Stark	32nd St. & Shea	—	—	3.77	—	—	(1)
31	Salt River Project	3900 E. Thomas	—	—	—	—	3.10	(1)
32	Ben Burke	24th St. & Indianola	—	—	4.87	—	—	(1),(9)
33	Paul E. Griffin	Alhambra 2NE	Trace	—	1.11	—	1.11	(2)
34	USBIA	Phoenix Indian School	.15	—	1.91	—	2.06	(2)
35	Scottsdale Fire Dept	Miller & Thomas	0	—	.20	—	.20	(2)
36	Olus Barnes	Tempe	0	—	.37	—	.37	(2)
37	Harold Orcutt	South Phoenix	.23	—	1.22	—	1.45	(2)
38	Univ of Ariz	Tempe Citrus	0	—	.45	—	.45	(2)
39	Do.	Mesa Exp. Farm	—	—	.43	—	—	(2)
40	USWB	Phoenix WSFO	.27	—	1.37	4 hrs.	1.64	(2),(8)
41	Bruce A. Cain	Deer Valley	.14	30 min.	.73	2 hrs.	.87	(2)
42	Willard Groene	Mummy Mountain	1.00	--	3.24	—	4.24	(2)
43	Earle Stewart	Laveen	0	—	.86	—	.86	(2),(7)
44	—	Black Canyon No. 13	0	—	.50	4 hr. 30 min.	.50	(3),(10)
45	—	Carefree No. 19	.05	30 min.	.81	3 hrs.	.86	(3)
46	—	Fort McDowell No. 23	.18	1 hr. 15 min.	.86	5 hrs.	1.04	(3)
47	—	Rock Springs No. 46	.01	—	.39	4 hr. 30 min.	.40	(3)
48	—	Skunk Creek No. N/A	0	—	.51	2 hrs.	.51	(3)
49	—	So. Mountain Park No. 53	0	—	.62	3 hrs.	.62	(3)
50	—	Thunderbird Academy No. 59	.91	1 hr.	1.46	3 hrs.	2.37	(3)

TABLE 1 (continued)

Gage No.	Name	Gage Location or Name of station	PRECIPITATION June 21 Amount	Period	June 22 Amount	Period	Storm Total (in)	Footnote references
51	Jeffery Carqueville	110 W. McNeil St. No. 38	.10	—	.60	—	.70	(3),(11)
52	V.V. Higginbotham	7514 E. Taylor No. 51	.15	—	.31	—	.46	(3)
53	Yettie M. Ferguson	11202 Nebraska Ave Youngtown No. 79	0	—	0	—	0	(3)
54	K.C. Schabinger	1-3/4 mi. N.E. Apache Junction No. 5	Trace	—	.20	—	.20	(3)
55	George M. Duren	11102 Iowa Ave Youngtown No. 69	0	—	0	—	0	(3)
56	Mrs. R. Morrow	Wenden No. 61	.01	—	0	—	.01	(3)
57	R.E. Bellinoff	3430 E. Coolidge St. No 39	.46	—	4.45	—	4.91	(3)
58	Martin Nerad	3 mi. NW of Hassayampa No. 26	0	—	0	—	0	(3)
59	R.G. Coker	11 mi. W of Arlington No. 36	0	—	0	—	0	(3)
60	J.W. Rogers	318 4th Ave West Valencia No. 14	0	—	0	—	0	(3)
61	Ollie Leppanen	541 W. Palm Lane No. 33	0	—	3.35	—	3.35	(3)
62	Harry Cram	Apache Junction No. 78	0	—	.17	—	.17	(3)
63	M.F. Currier	11325 Duluth Ave Youngtown No. N/A	0	—	0	—	0	(3)
64	Jim Terry	Ox Wash No. 80	0	—	0	—	0	(3)
65	Mrs. George Potts	12819 N. 22nd St. No. 53	.01	—	2.20	—	2.21	(3)
66	Tom Anderson	5250 N. 15th St. No. N/A	.22	—	3.44	—	3.66	(3)
67	Jay Vander Wall	529 S. Hobson No. 57	.50	—	.10	—	.60	(3)
68	Win Green	4920 N. 85th St.	.30	6 hrs.	.71	6 hrs.	1.01	(4)
69	Bob Gale	2902 E. Voltaire	.31	Do.	1.67	Do.	1.98	(4)
70	Glen Reagan	13823 N. 37th Pl.	.21	Do.	2.95	Do.	3.16	(4)

TABLE 1 (continued)

Gage No.	Name	Gage Location or Name of station	PRECIPITATION June 21 Amount	June 21 Period	June 22 Amount	June 22 Period	Storm Total (in)	Footnote references
71	Allan Hibbert	1442 E. Bishop Dr., Tempe	.11	Do.	.06	Do.	.17	(4)
72	Ross Watkins	1627 W. Geneva Dr., Tempe	†		†		.21	(4)
73	Bill McElvain	1867 E. Loma Vista Dr., Tempe	†		†		.25	(4)
74	Wendell Tolkerts	1315 E. Georgia	.10		4.00	4 hrs.	4.10	(5)
75	Maurice Bradford	24th St. & Camelback	.38	—	5.25	2 hrs.	5.63	(5),(12)
76	Ken Mullins	4007 N. 34th St.	.30		4.02		4.32	(6)
77	Do.	4218 N. 35th Way	.35	—	4.04	—	4.39	(6)
78	Lee Reagan	757 E. Montecito	.20	4 hrs.	2.95	4 hrs.	3.15	(5)

† Included in 12-hour total.
1 National Weather Service, unofficial stations.
2 National Weather Service, official stations.
3 USGS stations.
4 US Forest Service Data, private observers.
5 Response to newspaper request for data, private observers.
6 US Water Conservation Lab, private observers.
7 Gage - type unknown.
8 Recording Gage - type unknown.
9 CAN.
10 Recording Gage - Universal.
11 Nonrecording plastic rain gage.
12 Straight-sided jar, approx. 4 in. Dia.

TABLE 2

FLOOD STAGES AND DISCHARGES FOR 22 JUNE 1972
PHOENIX, SCOTTSDALE AND PARADISE VALLEY AREAS, ARIZONA

	Stream and place of station determination	Drainage area (sq. mi.)	Gage height (ft.)	Peak discharge (cfs)	Unit runoff (csm)
1	Shea Wash, SE 1/4 sec.23, T. 3N., R. 5E., at Shea Blvd nr Scottsdale	1.79	–	945	528
2	Shea Wash trib No. 3, SE 1/4 sec.23, T. 3 N., R. 5 E., at Shea Blvd nr Scottsdale	0.09	–	86	956
3	Shea Wash trib No. 2, SW 1/4 sec.23, T. 3 N., R. 5 E., at Shea Blvd nr Scottsdale	0.14	–	103	736
4	Shea Wash trib No. 1, SW 1/4 sec.23, T. 3 N., R. 5 E., at Shea Blvd nr Scottsdale	0.12	–	80	667
5	Indian Bend Wash trib No. 1, NW 1/4 SW 1/4 sec. 32, T. 3 N., R. 4 E., at Tatum Blvd in Paradise Valley	0.026	–	88	3,400
6	Indian Bend Wash trib No. 2, SE 1/4 SW 1/4 sec. 32, T. 3 N., R. 4 E., at Tatum Blvd in Paradise Valley	0.075	–	144	1,920
7	Indian Bend Wash, SW 1/4 sec. 34, T. 3 N., R. 4 E., at Camelback Country Club in Paradise Valley	83. 0	–	14,500	175
8	Indian Bend Wash (at Indian Bend Rd) nr Scottsdale (gaging station)	142.0	4.93	20,000	141
††9	Indian Bend Wash at Thomas Road in Scottsdale		7.98	14,300	–
10	Cudia City Wash nr Phoenix, SE 1/4 SE 1/4 sec. 7, T. 3 N., R. 4 E., 1,000 ft upstream from McDonald Drive	2.16	–	4,200	1,940
11	Cudia City Wash trib at 40th St and Rancho Drive, NE 1/4 NE 1/4 sec. 13, T. 2 N., R. 3 E.	0.08	–	219	2,750
12	Dreamy Draw (at 16th St) at Phoenix, SW 1/4 SW 1/4 sec. 34, T. 3 N., R. 3 E.	1.62	–	860	530

†† Slope-area survey run at Roosevelt St.

TABLE 3

COMPARISON OF PEAK DISCHARGES FOR
MAJOR RECORDED FLOODS IN THE PHOENIX, ARIZONA AREA

Number	Location	Date	Drainage area (sq. mi.)	Peak discharge (cfs)	Discharge (cfs/sq. mi.)
1	Shea Wash, SE 1/4 sec. 23, T. 3 N. R. 5 E., at Shea Blvd nr Scottsdale	*June 1972	1.79	945	528
2	Shea Wash trib No. 3, SE 1/4 sec. 23, T. 3 N., R. 5 E., at Shea Blvd nr Scottsdale	*June 1972	.09	86	956
3	Shea Wash trib No. 2, SW 1/4 sec. 23, T. 3 N., R. 5 E., at Shea Blvd nr Scottsdale	*June 1972	.14	103	736
4	Shea Wash trib No. 1, SW 1/4 sec. 23, T. 3 N., R. 5 E., at Shea Blvd nr Scottsdale	*June 1972	.12	80	667
5	Indian Bend Wash trib No. 1, NW 1/4 SW 1/4 sec. 32, T. 3 N., R. 4 E., at Tatum Blvd in Paradise Valley	*June 1972	.026	88	3,400
6	Indian Bend Wash trib No. 2, SE 1/4 SW 1/4 sec. 32, T. 3 N., R. 4 E., at Tatum Blvd in Paradise Valley	*June 1972	.075	144	1,920
7	Indian Bend Wash, SW 1/4 sec. 34, T. 3 N., R. 4 E., at Camelback Country Club in Paradise Valley	*June 1972	83.	14,500	175
8	Indian Bend Wash (at Indian Bend Rd) nr Scottsdale (gaging station)	*June 1972	142.	20,000	141
9	Cudia City Wash nr Phoenix SE 1/4 SE 1/4 sec. 7, T. 3 N., R. 4 E., 1,000 ft. upstream from McDonald Drive	*June 1972	2.16	4,200	1,940
10	Cudia City Wash trib at 40th St and Rancho Drive, NE 1/4 NE 1/4 sec. 13, T. 2 N., R. 3 E.	*June 1972	.08	219	2,750
11	Dreamy Draw (at 16th St) at Phoenix, SW 1/4 SW 1/4 sec. 34, T. 3 N., R. 3 E.	*June 1972	1.62	860	530

TABLE 3 (Continued)

COMPARISON OF PEAK DISCHARGES FOR
MAJOR RECORDED FLOODS IN THE PHOENIX, ARIZONA AREA

		Date	Drainage area (sq. mi.)	Peak discharge (cfs)	Discharge (cfs/sq. mi.)
12	Hassayampa R. @ Box Damsite (nr Wickenburg) SE 1/4 sec. 7, T. 8 N., R. 4 W.	Sept. 1970	417.	58,000	139.09
13	New R. nr Glendale NE 1/4 NW 1/4, sec. 8, T. 2 N., R. 1 E.	Sept. 1970	323.	19,200	59.44
14	New R. nr. Rock Springs SW 1/4 SW 1/4, sec. 6, T. 7 N., R. 3 E.	Sept. 1970	67.3	18,600	276.37
15	New R. at Glendale	Dec. 1967	323.	19,800	61.30
16	Skunk Cr. nr Phoenix SE 1/4, sec. 35, T. 5 N., R. 2 E.	Dec. 1964	64.6	11,500	178.02
17	New R. @ New R. SE 1/4 NW 1/4, T. 7 N., R. 2 E.	Dec. 1970	85.7	19,500	227.54
18	IBW nr Scottsdale SE 1/4, sec. 2, T. 2 N., R. 4 E.	June 1972	142.	20,000	140.84
19	Cave Cr. nr Cave Cr. SW 1/4, sec. 12, T. 5 N., R. 3 E.	Dec. 1967	121.	12,400	102.48
20	New R. nr Rock Springs	Dec. 1967	67.3	10,600	157.50
21	New River at Peoria NE 1/4 NE 1/4, sec. 3, T. 3 N., R. 1 E.	Aug. 1943	187.	38,000	203.21
22	Agua Fria R. @ Avondale NW 1/4, sec. 14, T. 1 N., R. 1 W.	Jan. 1916	2,013	105,000	52.16
23	Agua Fria R. @ Avondale	Nov. 1919	2,013.	105,000	52.16
24	Sycamore Cr. nr Ft. McDowell sec. 16, T. 4 N., R. 8 E.	Sept. 1970	165.	24,200	146.67
25	Queen Cr. Superior @ Whitlow Ranch Dam site.	Aug. 1954	144.	42,900	297.92

* June 22, 1972

FLOOD DAMAGES

17. GENERAL. Damage data were collected and evaluated by personnel of the Los Angeles District in cooperation with many Federal, State, County, City and local agencies - including the U. S. Soil Conservation Service; the U. S. Geological Survey; the U. S. Forest Service; the U. S. Air Force; the Arizona State Highway Department; the Arizona State National Guard; the Arizona State Civil Defense; the Maricopa County Flood Control District and the Maricopa County Highway Department; the Engineering, Water and Sewers, Sanitation, Parks, Playgrounds and Recreation, and Street Maintenance Departments of the City of Phoenix; the Scottsdale City Public Works and Park and Recreation Departments; the Salt River Project; the American Red Cross; and the Mountain Bell Telephone Company. Local business establishments and local residents also supplied valuable data on flood damages.

18. The principal areas of flood damage are shown on pl. 7 through 19. These areas were along a 14-mile-long reach of Indian Bend Wash; along 16 miles of the Arizona Canal from Cave Creek to Indian Bend Wash; along breaks in the Arizona Canal at 23d Avenue, Central Avenue, 7th Street, 12th Street, 16th Street, 20th Street, 32d Street, and 40th Street; along 8 miles of Grand Canal, from 15th Avenue to 44th Street; and along breaks in the Grand Canal at 12th Avenue, Central Avenue, 7th Street, and Longview Avenue.

19. The principal population centers affected by overflow from Indian Bend Wash and the Arizona and Grand Canals are: Phoenix along Indian Bend Wash, the Arizona Canal, and the Grand Canal; Scottsdale and Tempe along Indian Bend Wash and the Arizona Canal; and Paradise Valley along Indian Bend Wash.

20. Flood damages consisted of physical damages; emergency costs resulting from evacuation, flood fighting, relief, and use of alternative facilities; and business losses due to delays, increased costs of operation, and lost income.

21. The flooded areas and the extent of damages are described in the following paragraphs.

22. INDIAN BEND WASH. This report considers only that part of Indian Bend Wash extending from Hearn Road in Paradise Valley to the Salt River. Indian Bend Wash, for the purposes of this report, has been divided into two reaches - Upper Indian Bend Wash, which lies above the Arizona Canal, and Lower Indian Bend Wash, which lies below the Arizona Canal. Upper Indian Bend Wash extending from Hearn Road to the Arizona Canal, a distance of 8 miles, has a drainage area of 142 square miles. Lower Indian Bend Wash extending from the Arizona Canal to the Salt River, a distance of 7 miles, drains an additional area of 59 square miles. Each of these reaches has been further divided into two subreaches, all of which are discussed in the following subparagraphs.

Silt deposit was a major problem along Indian Bend Wash as is evident from this view of homes north of Thomas Road in Scottsdale.

Silt was also deposited on properties along Indian Bend Wash near McKellips Road in the City of Tempe.

23. UPPER INDIAN BEND WASH (HEARN ROAD TO SCOTTSDALE ROAD IN PARADISE VALLEY). The flooded area along this reach of Indian Bend Wash and the tributaries to the wash in the vicinity of wash amounted to 2,350 acres. The flooded area along this reach is shown on pl. 7 and 8. In addition minor flooding ocurred outside this area. Although winds caused the most severe damage in Paradise Valley, sheetflow with a depth ranging from 1 to 2 feet throughout the valley caused total flood damages estimated at about $250,000.

A street sign is the only evidence of the intersection as sheetflow covers Shea Blvd. and 50th Street in Paradise Valley.

A summary of estimated damages appears in table 4. The following subparagraphs give pertinent information on damages along this reach.

a. Damages to residential property. Sheetflow in the area north of Indian Bend Wash between 64th Street and Scottsdale Road caused flood damages to about 66 homes. Most of the damage occurred to landscaping, but floodwaters entered some homes causing extensive damage to their contents. Sheetflow inundated about 37 homes south of Shea Boulevard between 56th and 64th Streets. Again, most of the damage occurred to the landscaping; floodwaters damaged the contents of only a few of these homes. About 57 additional homes, scattered over the area, were damaged by the flood. In summary, about 160 homes sustained flood damages estimated at about S184,000.

Floodwater from a tributary of Indian Bend Wash converted landscaping into an island near these homes at 58th place in Paradise Valley.

b. Damages to public property. Costs incurred by the Town of Paradise Valley for floodfighting and for the removal of debris and silt in the valley are included under this category. Public property damage is estimated at $4,000.

c. Damages to parks and recreation areas. Floodwaters with a depth of about 3 feet and a velocity of 4 feet per second (f.p.s.) inundated a golf course in the wash west of Scottsdale Road. A few trees were washed out and silt was deposited on the turf. Ponded water remained on the course for about a week and a half resulting, in loss of revenue. Total estimated damages are $15,000.

d. Damages to agricultural property. Agricultural property in Paradise Valley incurred minor damages estimated at $3,000.

e. Damages to streets, roads, and bridges. The streets most severely damaged during the flood were Shea Boulevard and Double Tree Ranch Road. Segments of pavement were washed out and silt was deposited on the streets. The total damages to streets were about $4,000.

f. Damages to utilities. The only damages to utilities consisted of damages to the telephone system. The total damages were about $40,000.

24. UPPER INDIAN BEND WASH (SCOTTSDALE ROAD TO THE ARIZONA CANAL IN THE CITY OF SCOTTSDALE). Flooding occurred in an area east of Scottsdale Road to the Arizona Canal south of Indian Bend Road in the City of Scottsdale. The flooded area, amounting to 850 acres, is shown on pl. 8 and 9. The discharge at the gaging station on Indian Bend Road was about 20,000 c.f.s. Also, at Indian Bend Road, floodwaters with a discharge of about 3,000 c.f.s. flowed along the Arizona Canal and remained above the canal, damaging private property. The damages that were sustained in that area are described under the section covering the Arizona Canal in the City of Scottsdale. The total flood damages on Upper Indian Bend Wash in the City of Scottsdale were about $231,000. A summary of estimated damages appears in table 4. The following subparagraphs give pertinent information on damages along this reach.

a. Damages to residential property. About six homes above the Arizona Canal were flooded. The water depth ranged from 1 to 2 feet. Muddy waters with a depth of a few inches flooded the inside of some homes damaging carpets and contents. Residential damages were about $29,000.

b. Damages to public property. Damages in this category was the cost of the removal of debris and silt by the City of Scottsdale. The flood damages to public property were about $1,000.

c. Damages to parks and recreation areas. A golf course in the wash north of Indian Bend Road was flooded by muddy waters ranging from 1 to 4 feet in depth. The turf in the fairway was damaged and silt was deposited in the lakes on the course. Total estimated damages are $152,000.

Floodwaters inundated the golf course above the Arizona Canal and overtopped the flood gates and spillway on the canal.

d. Damages to agricultural property. Five ranches above the Arizona Canal were damaged when floodwaters ranging in depth from 1 to 2 feet deposited silt and debris on the land. A horse- riding ranch south of Indian Bend Road was covered with silt and debris. The total damages to agricultural property were about $29,000.

Horses wade through knee-deep floodwaters on a farm near Arizona Canal and Pima Road.

e. Damages to streets, roads, and bridges. Roads damaged during the flood were Scottsdale and Indian Bend Roads. Silt had to be removed and the pavement repaired. The total damages, including loss caused by delay and extra traveling, were about $20,000.

25. LOWER INDIAN BEND WASH (ARIZONA CANAL TO McKELLIPS ROAD IN THE CITY OF SCOTTSDALE). The flooded area in this reach, amounting to 1,000 acres, is depicted on pl. 9 and 10. Flooding occurred when the floodwaters overtopped the spillway of the Arizona Canal and the canal banks, causing numerous breaks in the southern part of the canal.

Floodwaters escaping through breaks in the south bank of the Arizona Canal damaged a farm below the canal.

The average depth of water in the flooded areas ranged from 3 to 5 feet with velocities ranging from 4 to 7 f.p.s. The damages to a greenbelt area, two parks, and three golf courses were about $135,000. The total damages were about $1,087,000. A summary of estimated damages appears in table 4. In addition, the floodwaters claimed a life when a 30-year-old man drowned while swimming in the wash south of Chaparral Road. The following subparagraphs give pertinent information on damages along this reach.

a. Damages to residential property. Damages to residential property occurred when the floodwaters exceeded the capacity of the wash at 78th Street and inundated areas north of Osborn Road and Thomas Road. Floodwaters in this area damaged 128 homes ranging in value from $25,000 to $35,000. The water depth in the homes ranged from a few inches to over 2 feet. About 30 homes south of McDowell Road were also inundated. Although these homes had been condemned and relocation was in progress, many of the homes were still occupied. When the flood occurred, these residents had to be rescued. A few other houses scattered along the wash sustained damages. In summary, about 160 homes sustained flood damages. Included under this category also are the funds expended by the American Red Cross and the Arizona National Guard for the care and rescue of the flood victims during the flood, particularly the flood victims south of McDowell Road. The total damages to residential property were about $211,000.

Persons on Osborn Rd. view the damages caused by floodwaters from Indian Bend Wash which inundated a farm and several homes in the area.

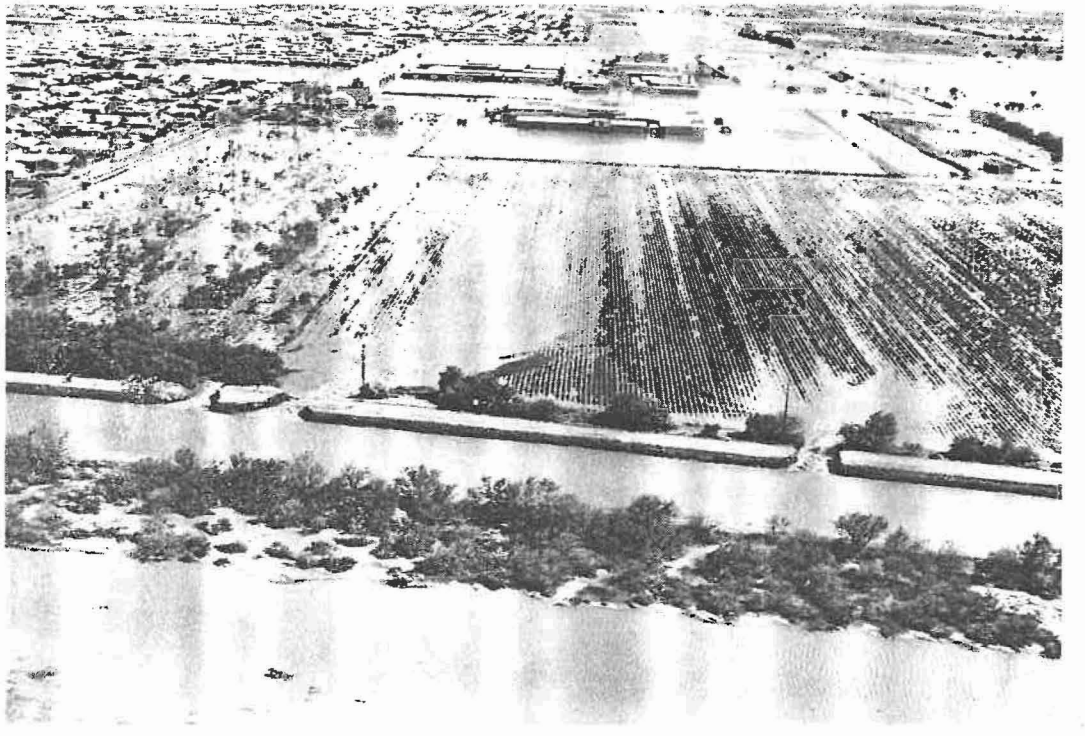
Floodwaters from Indian Bend Wash inundated homes, yards, and streets to the left of Thomas Road.

Roofs of these condemned homes became islands when Indian Bend Wash flooded west of McDowell Road.

b. Damages to commercial property. Floodwaters exceeded the capacity of the wash and inundated and deposited debris and silt on the grounds of two gas stations, a pizza parlor, and a drive-in on the corner of Hayden Road and Indian School Road. Water depths at the above location ranged from 6 inches to 2 feet. Floodwaters also exceeded the capacity of the wash at McDowell Road, damaging landscaping and contents of a used car dealership, an electrical contractor shop, a cocktail bar, and a trailer sales establishment. Also a gas station on McDowell Road has silt deposited on the grounds. Water depths here ranged from 8 inches to 1-1/2 feet. Above McKellips Road at Pierce Street, a plating business was physically damaged and a restaurant suffered business losses. In summary, 11 commercial establishments were damaged in the amount of about $186,000, of which $169,000 were business losses and emergency costs.

Commercial establishments on McDowell Road in Indian Bend Wash were flooded.

c. Damages to public property. Public property in this reach sustained more damage than any other type of property. Saguaro High School and Pueblo Elementary School sustained damages to landscaping and contents in the amount of $85,000. The outside water depth was about 1- 1/2 feet; the water depth inside the buildings ranged from 4 to 8 inches.



These breaks in the Arizona Canal enabled floodwaters to damage an elementary school, a high school, and some farmland.

d. Damages to parks and recreation areas. A subdivision golf course on Indian School Road was inundated. In a greenbelt area, the flood damaged one golf course on Chaparral Road, two golf courses south of Thomas Road, a park on Oak Street, and another park on Roosevelt Road; damages consisted of silt deposition on the grounds and damages to the landscape. Water depth ranged from 3 to 5 feet with velocities ranging from 4 to 7 f.p.s. Total estimated damages to the greenbelt area were $135,000.

Floodwaters in Indian Bend Wash forced these residents below McDowell Rd. to seek safety on the car and the roof of the house.

Two water wells on Indian School Road and on Thomas Road were also damaged. As a result of the deposition of debris and silt, the City of Scottsdale was required to undertake a cleanup program, resulting in expenditures of $20,000. The special floodfighting efforts and rescue mission by the City of Scottsdale, the U.S. Air Force Rescue Squad, and Luke Air Force Base minimized the flood damages. The total damages to public property were about $192,000.

Floodwaters over 4 feet deep make the trees in El Dorado Park at Oak Street look like shrubs.

Another view of El Dorado Park looking north from Mc Dowell Road.

e. Damages to agricultural property. Several farms were flooded. At the intersection of the Arizona Canal and Indian Bend Wash, dairy farm equipment and contents downstream from the south bank of the canal were inundated to a depth of about 3-1/2 feet. Floodwaters ranging in depth from 2 to 4 feet also damaged the contents of two farms east of the Arizona Canal between Indian School Road and McDonald Road. Other flooded farms include three farms east of the canal near McDonald Road (cleanup of silt deposition); a farm south of the canal next to the Pueblo Elementary School (damage to contents); one at Camelback Road (cleanup of silt deposition); one at Indian School Road (damage to contents); and two farms near Thomas Road (cleanup of silt deposition). The estimated flood damages for these 11 farms amounted to $87,000.

At the intersection of the Arizona Canal and Indian Bend Wash floodwaters damaged agricultural property and a dairy farm.

f. Damages to streets, roads, and bridges. Floodwaters damaged the pavement and deposited silt in following streets and roads that cross Indian Bend Wash: Camelback Road, Indian School Road, Osborn Road, Thomas Road, Oak Street, McDowell Road, Roosevelt Street, and McKellips Road. Other roads damaged were Hayden and Miller Roads. Many people experienced delays and extra traveling as a result of such physical damage. The total damages to streets, roads, and bridges were about $180,000.

g. Damages to utilities. Damage occurred to the contents of an electrical installation plant between Chaparral Road and McDonald Drive, the electrical distribution system, and the telephone system. Interruption in services was slight due to the flood-preventive efforts of utility companies. The total damages to utilities were about $29,000.

h. Damages to stream channels. Silt and debris were deposited along the lower Indian Bend Wash. Land along the banks was lost due to the erosive velocity of floodwaters within the wash. The total damages to stream channels were about $32,000.

i. Damages to irrigation works. The floodwaters overtopped the Arizona Canal where it intersects Indian Bend Wash, causing numerous breaks east of the wash on the south bank of the canal. The spillway at this intersection was also overtopped. Repairs to the Arizona Canal consisted of restoring the various washouts; rebuilding the roads and bank; and redigging and leveling the pump ditch. The total damages to the irrigation works were about S35,000.

26. LOWER INDIAN BEND WASH (McKELLIPS ROAD TO THE SALT RIVER IN THE CITY OF TEMPE). The flooded area in this reach is shown on pl. 10 and amounts to 450 acres. The floodwaters exceeded the capacity of the wash, damaging properties along and adjacent to the wash. The water depth ranged from 1/2 to 3 feet outside and from a few inches to 2 feet inside the structures. Commercial property sustained the most severe damages – about $247,000. The total damages in all categories were about $372,000. A summary of estimated damages appears in table 4. The following subparagraphs give pertinent information on the damages in this reach.

a. Damages to residential property. Residential property was damaged when floodwaters exceeded the capacity of the wash in the general area bounded on the north by McKellips Road, on the south by Princess Drive, on the west by Scottsdale Road, and on the east by Miller Road. Damages occurred to 52 homes when floodwaters ranging in depth from a few inches to 2 feet entered the homes and damaged carpets and contents. The depth of the floodwater inside the homes ranged from a few inches to a foot. Many houses whose foundations were about 1 foot above ground level suffered only yard damages. The value of the houses ranged from $10,000 to $20,000. Included in the damages in this category are the funds expended by the Arizona National Guard for the care and rescue of the flood victims during the flood. The total damages to residential property were about $48,000.

These homes near Princess Drive in Tempe were inundated.

b. Damages to commercial property. Floodwaters damaged numerous commercial businesses on Princess Drive, Scottsdale Road, and Hayden Road. Some businesses sustained damages to contents but most of the drainages resulted from cleanup operation. The businesses included auto shops, boating shops, printing shops, a welding shop, a supply store, a paving company, a concrete supply company, a nightclub, a radio station, a race track, a salvage yard, and the Big Surf, a recreation center for surfers. The floodwater depth ranged from 1/2 to 2 feet outside and from a few inches to 1 foot inside the structures. A total of 39 commercial businesses were affected by the floodwaters in this reach. The total damages to commercial property were about $247,000.

c. Damages to industrial property. Most of the flood-damaged industrial property was along Scottsdale Road and Princess Drive north of the Salt River. The industrial properties included construction companies and manufacturers of plastics, springs, sheet metals, stakes, and electronic parts. The floodwater depth ranged from 1/2 to 2 feet. The depth of floodwaters in the structures ranged from a few inches to 1 foot. A total of 14 industrial businesses sustained flood damages to equipment and yards in the amount of about $68,000.

d. Damages to public property. Flood damages in this category were relatively minor. The property damaged consisted of a pet mortuary that had damages to contents and an animal shelter on Scottsdale Road that had silt and debris deposited on the parking lot. The total damages to public property were about S4,000.

e. Damages to agricultural property. Floodwaters inundated two ranches next to the wash south of McKellips Road, damaging corrals, pens, and storage areas and depositing silt and debris. The fence and yard of a greyhound ranch on Scottsdale Road south of Princess Drive were also damaged. These three agricultural units had flood damages of about $2,000.

Indian Bend Wash was converted into a smooth plain of water damaging a farm near McKellips Road.

f. Damages to stream channels. Damages in this category included the deposition of silt and debris along the wash and the loss of land due to erosion. The total damages to stream channels were about S3,000.

TABLE 4

SUMMARY OF FLOOD DAMAGES FROM THE 22 JUNE 1972 FLOOD ALONG

INDIAN BEND WASH

Area of flooding Type of property	Upper Indian Bend Wash Paradise Valley (2,350 ac.)	 City of Scottsdale (850 ac.)	Lower Indian Bend Wash City of Scottsdale (1,000 ac.)	 City of Tempe (450 ac.)
Residential:				
Physical damage	$167,000	$ 26,000	$ 174,000	$ 37,000
Business loss and emergency cost	17,000	3,000	37,000	11,000
Commercial:				
Physical damage	–	–	17,000	148,000
Business loss and emergency cost	–	–	169,000	99,000
Industrial:				
Physical damage	–	–	–	53,000
Business loss and emergency cost	–	–	–	15,000
Public:				
Physical damage	1,000	1,000	125,000	3,000
Business loss and emergency cost	3,000	0	67,000	1,000
Parks and recreation areas:				
Physical damage	1,000	150,000	84,000	–
Business loss and emergency cost	14,000	2,000	51,000	–
Agricultural:				
Physical damage	2,000	17,000	73,000	1,000
Business loss and emergency cost	1,000	12,000	14,000	1,000
Streets, roads, and bridges:				
Physical damage	3,000	4,000	36,000	–
Business loss and emergency cost	1,000	16,000	144,000	–
Utilities:				
Physical damage	32,000	–	26,000	–
Business loss and emergency cost	8,000	–	3,000	–
Stream channels:				
Physical damage	–	–	30,000	2,000
Business loss and emergency cost	–	–	2,000	1,000
Irrigation works:				
Physical damage	–	–	32,000	–
Business loss and emergency cost	–	–	3,000	–
Subtotal, physical damage	206,000	198,000	597,000	244,000
Subtotal, business loss and emergency cost	44,000	33,000	490,000	128,000
Total	$250,000	$231,000	$1,087,000	$372,000

Grand Total - Upper and Lower Indian Bend Wash - $1,940,000

27. ARIZONA CANAL. Flooding occurred along and below the Arizona Canal. For the purposes of this report, the area above the Arizona Canal is divided into two reaches the Scottsdale area, from the Indian Bend Wash intersection to 64th Street, and the Phoenix area, from 64th Street to Cave Creek. The area below the canal is discussed in the section titled "Breaks in the Arizona Canal."

28. ARIZONA CANAL (Indian Bend Wash intersection to 64th Street in Scottsdale). This reach is about 4 miles long. Floodwaters from Indian Bend Wash flowed towards and alongside the Arizona Canal causing flood damages above the canal. Water ponded along the canal with depths of 1-1/2 to 3-1/2 feet. The flooded area, amounting to 300 acres, is shown on pl. 11 and 12. The major damages along the Arizona Canal in the City of Scottsdale accrued to ($804,000) residential property and commercial property ($365,000). Minor flood damages occurred to agricultural property ($6,000); public property ($4,000); utilities ($5,000); and to streets, roads, and bridges ($3,000). A summary of the total damages, estimated at $1,187,000, is shown in table 5. The following subparagraphs give pertinent flood damage information for the major damages in this reach.

Residential property above the Arizona Canal in the vicinity of 68th Street in Scottsdale also was damaged by silt deposits.

Commercial property above the Arizona Canal at Scottsdale and Camelback Roads in Scottsdale was inundated by floodwaters, silt, and debris.

a. Damages to residential property. Residential market values ranged from S30,000 to S60,000. Floodwaters from Indian Bend Wash, which carried large quantities of debris and silt, damaged carpets and furniture. Outside water depths ranged from 1-1/2 to 3-1/2 feet. The depths of floodwaters inside the damaged properties varied according to the efforts of the residents to keep the water out. Business losses of about S96,000 consisted of time loss from work and the cost of temporary lodging. Total residential damages amounted to about $804,000.

Rowboat navigates Woodmere Fairway when floodwaters 4-feet deep inundated a residential area above the Arizona Canal north of Camelback Road in Scottsdale.

Muddy waters inundated these homes above the Arizona Canal along La Fayette Blvd. in Scottsdale.

b. Damages to commercial property. A car agency at Camelback and Scottsdale Roads was inundated with 2 feet of water.

Car agency at Camelback and Scottsdale Roads in Scottsdale is surrounded by debris and silt-carrying waters that ponded above the Arizona Canal.

About 19 commercial establishments sustained flood damages east of Scottsdale Road and north of Camelback Road. The shopping center at Camelback and Scottsdale Roads also sustained flood damages.

Residents wade through hip-high floodwaters that swamped businesses on Scottsdale Road north of Camelback Road in Scottsdale.

The largest commercial establishment damaged by floodwaters was the Safari Hotel complex, also at Scottsdale and Camelback Roads. Waters up to 3 feet were reported in the parking lots. Patrons in the hotel restaurant were in waters up to their knees. The estimated damages to commercial property totaled $365,000.

Patrons resort to floating their luggage when floodwaters engulfed this hotel on Scottsdale Road north of Camelback Road in Scottsdale.

Automobiles are almost submerged in floodwaters that filled the interior patio of the same hotel in Scottsdale.

29. ARIZONA CANAL (64th Street to Cave Creek in Phoenix). This reach, is about 12 miles long, was flooded mostly by the backwater from local runoff ponded along and above the canal bank. The flooded area along this reach of the Arizona Canal amounting to 500 acres, is shown on pl. 13 through 16. Flood damages in this part of the City of Phoenix totaled about $608,000. The major damages occurred to residential, commercial, and public properties as well as irrigation works. Such sustained damages totaled $584,000. Minor damages occurred to park and recreation areas ($9,000); to streets, roads, and bridges ($6,000); and to utilities (S9,000). A summary of damages sustained by various types of property is shown in table 5. The following subparagraphs give pertinent information on the major flood damages along this part of the canal.

a. Damages to residential property. Homes and properties directly above the canal were the hardest hit by the flood. Damages occurred mostly to contents and landscaping. Because local drainage facilities were not sufficient to carry the floodwaters across the canal, ponding occurred. Outside water depths in the flooded area ranged from 1 to 3 feet. Business losses of about $60,000 consisted of loss of time, the cost of temporary lodging and the costs of the American Red Cross for emergency aid to the residents. Damages to residential properties totaled about $478,000.

Residents wade in and out of home above the Arizona Canal at 13th Street and Orangewood Avenue in Phoenix.

Another inundated home at 13th Street and Orangewood Avenue in Phoenix.

b. Damages to commercial property. Water inundated the basement and the ground floor of the Arizona Biltmore Hotel north of the Biltmore Golf Course, damaging much of the operating equipment. In general, flood damages to commercial establishments were minimal because few commercial areas exist above the canal. Total commercial damages were estimated at $29,000.

c. Damages to public property. Included in this category are the emergency costs of the police department. The total estimated public damages were $15,000.

d. Damages to parks and recreation area. Floodwaters flooded the Granada Park on 20th Street above the Arizona Canal. About 1,000 yards of grass was destroyed and 10 trees were washed out. The park was closed for about 1 week. Total damages were estimated at $9,000.

e. Damages to streets, roads, and bridges. Floodwaters in streets and roads caused delays to motorists, and deposited silt in the roadways. The cost of delays, cleanup, and traffic control was estimated at $6,000.

f. Damages to utilities. Damages to utility facilities consisted of flood damages to the electrical and telephone systems along the canal. Total damages to utilities were about $9,000.

g. Damages to irrigation works. Floodwaters overtopped the canal banks at various locations and destroyed levees. Trash accumulated at trash grates and the debris had to be removed. Damages and emergency cost totaled about $62,000.

TABLE 5

SUMMARY OF FLOOD DAMAGES ABOVE THE ARIZONA CANAL
FROM THE 22 JUNE 1972 FLOOD

Area of flooding Type of property	City of Scottsdale (300 ac.)	City of Phoenix (500 ac.)
Residential:		
Physical damage	$708,000	$418,000
Business loss and emergency cost	96,000	60,000
Commercial:		
Physical damage	288,000	22,000
Business loss and emergency cost	77,000	7,000
Public:		
Physical damage	2,000	0
Business loss and emergency cost	2,000	15,000
Parks and recreation areas:		
Physical damage	—	4,000
Business loss and emergency cost	—	5,000
Agricultural:		
Physical damage	5,000	—
Business loss and emergency cost	1,000	—
Streets, roads, and bridges:		
Physical damage	1,000	4,000
Business loss and emergency cost	2,000	2,000
Utilities:		
Physical damage	1,000	8,000
Business loss and emergency cost	4,000	1,000
Irrigation works:		
Physical damage	—	56,000
Business loss and emergency cost	—	6,000
Subtotal, physical damage	1,005,000	512,000
Subtotal, business loss and emergency cost	182,000	96,000
Total	1,187,000	608,000
Grand Total	$1,795,000	

30. BREAKS IN THE ARIZONA CANAL. Pertinent information on damages due to breaks on the south bank of the Arizona Canal is given in the following subparagraphs. A summary of damages is shown in table 6.

a. 23rd Avenue. At the junction of Cave Creek and the Arizona Canal near 23rd Avenue the floodwaters were confined in the creek. Floodwaters went over the spillway south of the canal, but caused no reported damage to a citrus grove below the spillway. The waters then flowed to Dunlap Avenue and were diverted into side streets and storm drains. Very little flooding occurred in this area because it was on the western fringe of the storm.

A view of the junction of Cave Creek and the Arizona Canal near 23rd Avenue in Phoenix.

b. Central Avenue. The Arizona Canal was breached at the southeast corner of the Central Avenue crossing. (See pl. 15.) The water depth was about 4 feet immediately below the canal.

Repairs are started on the break in the Arizona Canal's south bank east of Central Avenue in Phoenix.

The total damages resulting from this break were estimated at $315,000, the flooded area, amounting to 12 acres, is shown on pl. 15.

(1) Damages to commercial property. A restaurant on Central Avenue was flooded. The floodwaters, which were about 4 feet deep inside this building, caused total damages to contents estimated at S99,000. The floodwaters were then channeled into Central Avenue and diverted into side streets and storm drains. No damages were reported to commercial facilities or residences south of the restaurant.

(2) Damages to public property. The flood damaged a riding trail along Central Avenue between Northern Avenue and Bethany Home Road. Also included as damages under this category are the costs incurred by the fire and police departments for their assistance to flood victims. Total public damages were estimated at $16,000.

(3) Damages to streets, roads, and bridges. Floodwaters in streets and roads caused delays to motorists, but only minor physical damages to streets were reported. The costs of delays detours, and traffic control were estimated at $200,000.

c. 7th Street. Flooding occurred when floodwaters overtopped the spillway at the south bank of the Arizona Canal east of 7th Street. Outside water depth was estimated at 1 foot. The flooded area, amounting to 75 acres, is shown on pl. 15. The total flood damages in the 7th Street area were about $58,000.

An orchard is flooded when floodwaters overtopped the spillway of the Arizona Canal east of 7th Street in Phoenix.

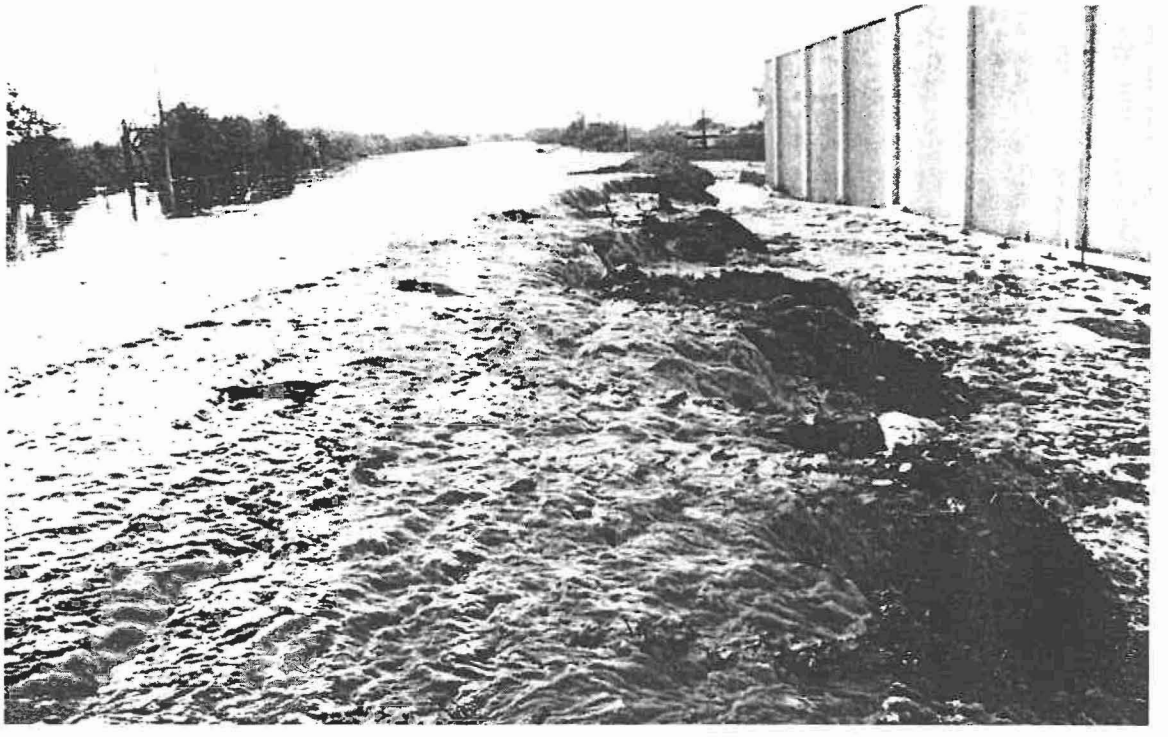
(1) Damages to residential property. Residential flood damage was limited to two homes and one apartment immediately below the canal. Most of the damage to contents was the result of silt deposition. Total damages to residential property were estimated at $6,000.

(2) Damages to agricultural property. The flood damaged an orchard below the spillway. Damages to this orchard were estimated at about $1,000.

(3) Damages to streets, roads, and bridges. Emergency costs under this category consisted of costs attributed to the control of travel and the delay caused to motorists. Total damages were estimated at $51,000.

d. 12th Street. This break in the Arizona Canal occurred when floodwaters overtopped the levee between Orangewood and Myrtle Avenues at the junction of Dreamy Draw Wash and the Arizona Canal. The flooded area, amounting to 15 acres, is shown on pl. 15. Flood damages in this area were not severe because the floodwaters dispersed before reaching the more densely developed residential area. Outside water depths ranged from a few inches to 1-1/2 feet. Total estimated damages amounted to $26,000, consisting of $16,000 in damages to 14 residences, $5,000 in damages to public property and $5,000 in damages to utilities.

e. 16th Street and 18th Place. Overtopping of the Arizona Canal at 16th Street was the major cause of the flood damages south of Glendale Avenue. Floodwaters with an estimated velocity ranging from 3 to 5 f.p.s. flowed across Lamar and Ocotillo Roads to Bethany Home Road before spreading out southward to the Grand Canal. Another break occurred near 18th Place, releasing floodflows that flowed along Ocotillo Road before crossing 16th Street. Outside water depths ranged from 6 inches to 1-1/2 feet. The flooded area, amounting to 115 acres, is shown on pl. 14. Flood damages resulting from these breaks were estimated at $82,000.



Floodwaters and debris gush over the top of the southern bank of the Arizona Canal east of 16th Street in Phoenix.

(1) Damages to residential property. Home values in the flooded area ranged from $12,000 to $20,000. The flood inundated about 56 homes causing damages estimated at $52,000 to contents and landscaping.

Residences below the Arizona Canal west of 16th Street in Phoenix were inundated when floodwaters overtopped the south bank.

(2) Damages to commercial property. A food market on Glendale Avenue south of the Arizona Canal sustained damages when floodwaters 4 feet deep partially destroyed its retaining wall and parking lot. A pizza parlor on 16th Street sustained damages to contents. The total damages to commercial property were about $20,000.

A Corps of Engineers employee reviews damages resulting from the 16th Street break in the Arizona Canal near Glendale Ave. in Phoenix.

(3) Damages to streets, roads, and bridges. Floodwaters in streets and roads caused delays to motorists, and deposited silt in the roadways. The cost of delays, cleanup, and traffic control was estimated at $5,000.

(4) Damages to utilities. Damages to utility facilities consisted of flood damages to the telephone system below the canal. Total damages to utilities were about $5,000.

f. 20th Street. The Arizona Canal overflowed its south bank near 20th Street in Phoenix. The overtopping which started about 400 feet southeast of Maryland Avenue extended for about 400 feet along the canal. The floodwaters flowed southwestward and rapidly spread out and diminished in depth. The flooded area amounting to 2 acres is shown on pl. 14. Outside water depths averaged about 6 inches. Total damages in this area accruing to 10 residences, were about $6,000.

g. 32nd Street and 40th Street. The flooding in this area, amounting to 2,800 acres, resulted from local runoff caused by the thunderstorms centered at 24th Street and Camelback Road and from floodwaters gushing from spillways and breaks in the canal. Floodwaters caused breaks in the south bank of the canal at 30th Street and 40th Street and overtopped the spillways at 30th Street, 32nd Street, and 40th Street. (See pl. 19)

Children play in floodwaters that overtopped the Arizona Canal spillway on the south bank west of 40th Street in Phoenix.

Floodwaters escape through a break in the Arizona Canal west of 40th Street in Phoenix.

The floodwaters combined near 28th Street and Indian School Road, then spread out until the waters ponded along the Grand Canal. The overflow area of about 5 square miles, extended from the Arizona Canal on the north to the Grand Canal on the south, and from 40th Street on the east to 12th Street on the west. Camelback Road from 40th Street to 16th Street resembled a river. Outside water depths ranged from 4 feet near the breaks to 1-1/2 to 2 feet near the Grand Canal. The floodwaters wiped out block-wall fences and caused serious structural damages. Total damages in this area were estimated at $3,768,000, 85 percent of which accrued to residential property.

Floodwaters inundate residences along 38th Place as shown in this view looking northwest from Camelback Road in Phoenix.

(1) Damages to residential property. The market values of homes in the overflow area ranged from $10,000 to $60,000 and up. Outside water depths, which varied according to the local terrain, averaged 2 to 4 feet. About 2,600 homes and 15 apartment complexes were flooded. Water depths inside the homes ranged from 1 inch to 2 feet and resulted in damages to carpets and contents. The apartment complex at 28th Street and Camelback Road, which had inside water depths of about 4 feet, incurred substantial damages. About 70 automobiles were damaged in the parking lot of the Cascades Apartments at 35th Street and Campbell Avenue. The damages ranged from $500 to $4,000 per home. The total residential damages resulting from the combined breaks amounted to about $3.2 million.

This house east of 32nd Street was severely damaged when floodwaters overtopped the spillway on the south bank of the Arizona Canal in Phoenix.

Homeowner on 38th Street and Camelback Road in Phoenix surveys damage from floodwaters and debris.

This family stands disconsolate in knee-deep floodwaters that entered their home at 38th Place and Camelback Road in Phoenix.

(2) Damages to commercial property. Commercial damages occurred throughout the overflow area. Large commercial complexes are along Camelback Road between 20th Street and 24th Street. Floodwaters estimated at 2,500 c.f.s. with a velocity of 5 f.p.s. swept through the Biltmore Shopping Center at 24th Street and Camelback Road that included some of the largest department stores in Phoenix. Outside water depths in the shopping areas ranged from 6 inches to 2 feet. Damages to contents and landscaping in the shopping center totaled about $265,000. In addition about 20 stores between 20th to 24th Street on Camelback Road also sustained damages in the amount of about $51,000. Total commercial damages resulting from the breaks were estimated at $316,000.

(3) Damages to public property. The Camelback High School at 28th Street and Campbell Avenue was damaged when floodwaters 5 inches to 1-1/2 feet deep entered the buildings and damaged carpets and contents. Also included in this category are the costs incurred by the fire and police departments for their assistance to flood victims. The total damages to public property were about $17,000.

c. 7th Street. Floodwaters overtopped the Grand Canal eastward about a quarter of a mile from 7th Street. The flood dug many small trenchs ranging from 1/2 to 1 foot in depth in the bank of the canal. Water depths ranged from 5 feet immediately below the canal bank to 1/2 foot at 7th Street and Renonshire Avenue. The flooded area amounted to 50 acres. The velocity of the floodflow which was high – over 5 f.p.s. – just below the bank decreased as the water flowed southward. Total damages in this area were about $233,000.

(1) Damages to residential property. The flood damaged the contents of 117 ground floor apartments along Roma and Turney Avenues. Total damages were about $162,000.

(2) Damages to commercial property. Fourteen stores on the east side of 7th Street were damaged by floodwaters. Building stones from a quarry below the canal were carried down 7th Street by the flood and posed a hazard to people trying to evacuate. Fortunately no one was injured. The total damages to commercial property were about $13,000.

(3) Damages to public property. No public property in this reach was damaged. Included in emergency cost under this category is the cost incurred by the police and fire department for their assistance to flood victims. Damages in this category totaled about $7,000.

(4) Damages to streets, roads, and bridges. No physical damages occurred to streets, although the flood did deposit silt on the roadways. Included in emergency cost is the cost for traffic control and for traffic delays. Total damages were S51,000.

d. Longview Avenue. Damages totaling about $15,000 occurred when floodwaters overtopped the bank of the Grand Canal between Longview Avenue and 13th Place. The depth of the water averaged about 1 foot and covered an area of 70 acres.

(1) Damages to residential property. Five residences accrued damages estimated at $7,000.

(2) Damages to public property. The North Phoenix High School was damaged when water 1 inch deep entered one of the buildings and damaged the carpet. The outside water depth was about 1-1/2 feet. Total damages to public property were about $8,000.

TABLE 7

SUMMARY OF FLOOD DAMAGES ALONG THE GRAND CANAL
AND RESULTING FROM BREAKS IN THE CANAL
FROM 22 JUNE 1972 FLOOD

Areas of flooding Type of property	Grand Canal in Phoenix (350 ac.)	Breaks in the Grand Canal 12th Ave. (60 ac.)	Central Ave. (140 ac.)	7th St. (50 ac.)	Longview Ave. (70 ac.)
Residential:					
Physical damage	$1,036,000	$132,000	$130,000	$149,000	$6,000
Business loss and emergency cost	118,000	10,000	10,000	13,000	1,000
Commercial:					
Physical damage	365,000	--	11,000	11,000	--
Business loss and emeregency cost	76,000	--	2,000	2,000	--
Public:					
Physical damage	15,000	--	65,000	0	6,000
Business loss and emergency cost	13,000	--	42,000	7,000	2,000
Parks and recreation areas:					
Physical damage	7,000	--	--	--	--
Business loss and emergency cost	1,000	--	--	--	--
Streets, roads, and brides:					
Physical damage	--	--	0	0	--
Business loss and emergency cost	--	--	201,000	51,000	--
Utilities:					
Physical damage	4,000	--	--	--	--
Business loss and emergency cost	1,000	--	--	--	--
Irrigation work:					
Physical damage	75,000	--	--	--	--
Business loss and emergency cost	6,000	--	--	--	--
Subtotal, physical damage	1,502,000	132,000	206,000	160,000	12,000
Subtotal, business loss and emergency cost	215,000	10,000	255,000	73,000	3,000
Total	1,717,000	142,000	461,000	233,000	15,000
Grand Total	$2,568,000				

34. SUMMARY OF DAMAGES FROM 22 JUNE 1972 FLOOD. The flooding along Indian Bend Wash, the Arizona Canal, and the Grand Canal and resulting from breaks in the Arizona and Grand Canals caused damages in the Phoenix metropolitan area totaling an estimated $10,558,000. The greatest damage resulted from the breaks in the Arizona Canal. Of these breaks, the ones at 32nd Street and 40th Street were responsible for the most damages - $3,768,000. Although the flood imperiled hundreds of lives and inconveniened thousands of people, only one life was lost. The following table summarizes the flood damages to the various types of property in the Phoenix metropolitan area:

TABLE 8

SUMMARY OF FLOOD DAMAGES FROM 22 JUNE 1972 FLOOD
IN THE PHOENIX METROPOLITAN AREA, ARIZONA

Type of property	Damages Physical damages	Business Loss and emergency cost	Total
Residential	$5,808,000	$834,000	$6,642,000
Commercial	1,183,000	546,000	1,729,000
Industrial	53,000	15,000	68,000
Public	233,000	175,000	408,000
Parks and recreation areas	249,000	74,000	323,000
Agricultural	99,000	29,000	128,000
Streets, roads, and bridges	52,000	869,000	921,000
Utilities	103,000	23,000	126,000
Stream channels	32,000	3,000	35,000
Irrigation works	163,000	15,000	178,000
TOTAL	$7,975,000	$2,583,000	$10,558,000

DAMAGES THAT WOULD HAVE BEEN PREVENTED BY CORPS OF ENGINEERS PROJECTS AUTHORIZED BUT NOT YET CONSTRUCTED

35. GENERAL. Two authorized flood control projects not yet constructed, would have provided flood protection during the flood of 22 June 1972 if they had been built. Pertinent information on these projects is given in the following subparagraphs.

a. Indian Bend Wash. The authorized project for Indian Bend Wash provides for a concrete- lined channel about 7 miles long, starting at the Arizona Canal and extending southward to the Salt River; and two earth levees upstream from the Arizona Canal to collect and direct the floodwaters towards the channel. If the project had been constructed at the time of the 1972 flood, floodwaters would have been contained downstream from Arizona Canal and floodflows from Indian Bend Wash would not have flooded along Arizona Canal. Flood damages estimated at about $1,400,000 along Indian Bend Wash and flood damages of about $1,200,000 along the Arizona Canal, a total of $2,600,000 would have been prevented.

b. Gila River Basin, New River and Phoenix City streams, Arizona. The authorized project provides for four detention basins, one each on Dreamy Draw, Cave Creek, unnamed tributary of Skunk Creek, and the New River; the Union Hills and the Arizona Canal diversion channels; and channel improvements for Dreamy Draw, Cave Creek, Skunk Creek, the New River, and the Agua Fria River. For the purposes of this report, Dreamy Draw Dam, which is presently under construction, will be discussed separately from the remainder of the project, which is in the planning stage.

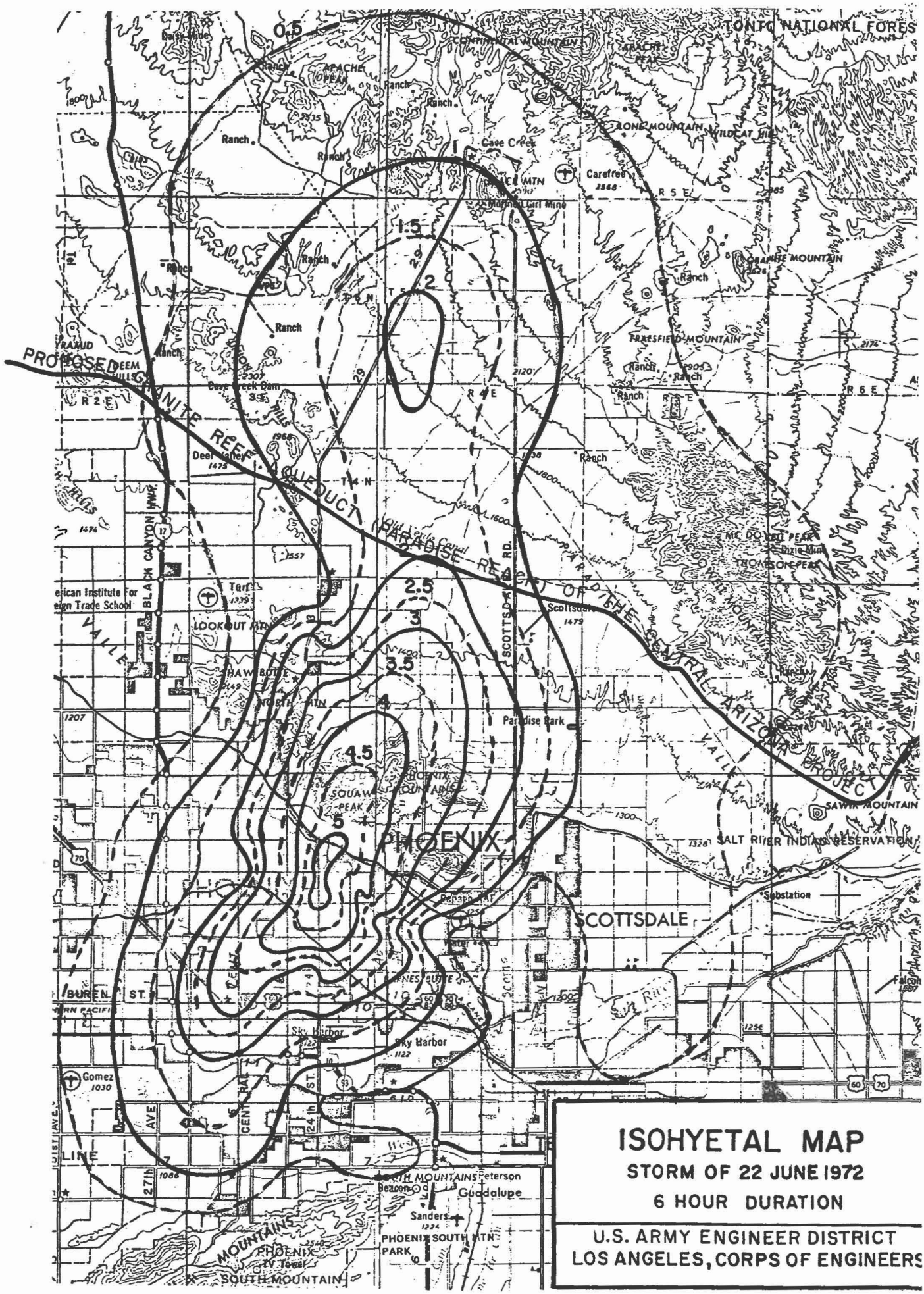
(1) Dreamy Draw Dam (under construction). The plan provides for a compacted, earthfill dam south of Northern Avenue and about 1 mile east of 16th Street to provide storage for flood control only. Construction of the dam was initiated in October 1972. At spillway crest, elevation 1,405, the reservoir would have a gross capacity of 317 acre-feet, including 36 acre-feet for sediment storage. The reservoir would regulate the standard project flood (reservoir-design flood) from a peak inflow of 3,600 c.f.s. to a maximum outflow of 196 c.f.s. The completed project will provide protection against floods for an overflow area of about 1,749 acres in the City of Phoenix. The estimated Federal first cost for Dreamy Draw Dam is $490,000 (1972) and the estimated total non-Federal first cost is $192,000 (1972). If the project had been constructed at the time of the 1972 flood, it would have prevented flood damages estimated at about $26,000, along the Dreamy Draw Wash.

(2) Remainder of the project (planning stage). The plan provides for controlling floodflows in each respective drainage area; for diverting residual flows in Cave Creek and several small washes to Skunk Creek; and for improving Skunk Creek, the New River, and the Agua Fria River to carry the residual flows to an adequate point of disposal in the Gila River. The project would protect an overflow area of about 40,800 acres in the cities of Phoenix, Peoria, and Avondale and unincorporated areas. The estimated Federal first cost for the total project including Dreamy Draw is $92,400,000 (1972), and the estimated total non-Federal first cost is $20,400,000 (1972). The Arizona Canal diversion channel, upstream and generally parallel to the Arizona Canal is the only unit of this group that would have significantly affected the flood situation. The project, if it had been constructed prior to the 1972 flood, would have prevented flood damages above and below the Arizona Canal estimated at about $400,000.

36. DAMAGES THAT WOULD HAVE BEEN PREVENTED BY GRANITE REEF AQUEDUCT (PARADISE REACH) ON THE CENTRAL ARIZONA PROJECT. The project would extend across Paradise Valley (see pl. 2) and provide for a detention levee to collect and hold floodwaters from the above drainage area. During the 21-22 June 1972 storm, the project if completed, would have collected the runoff from rainfall that averaged about 1-inch in intensity. This rainfall had little influence on the peak discharge along Indian Bend Wash at the Arizona Canal. This project, therefore, would have done little to prevent the flood drainage that occurred. The project would have had lesser influence on the flood situation – resulting from flows along and downstream from the Arizona and Grand Canals.

BIBLIOGRAPHY

37. The following data have been collected and are on file at the Corps of Engineers, Los Angeles District Office: newspaper accounts of the floods; plates and tables concerning high-water marks, and flood outlines; a U.S. Geological Survey report on the flood; a Channel 12 TV news film of the flood; and a photographic record of all areas of major flood damage.



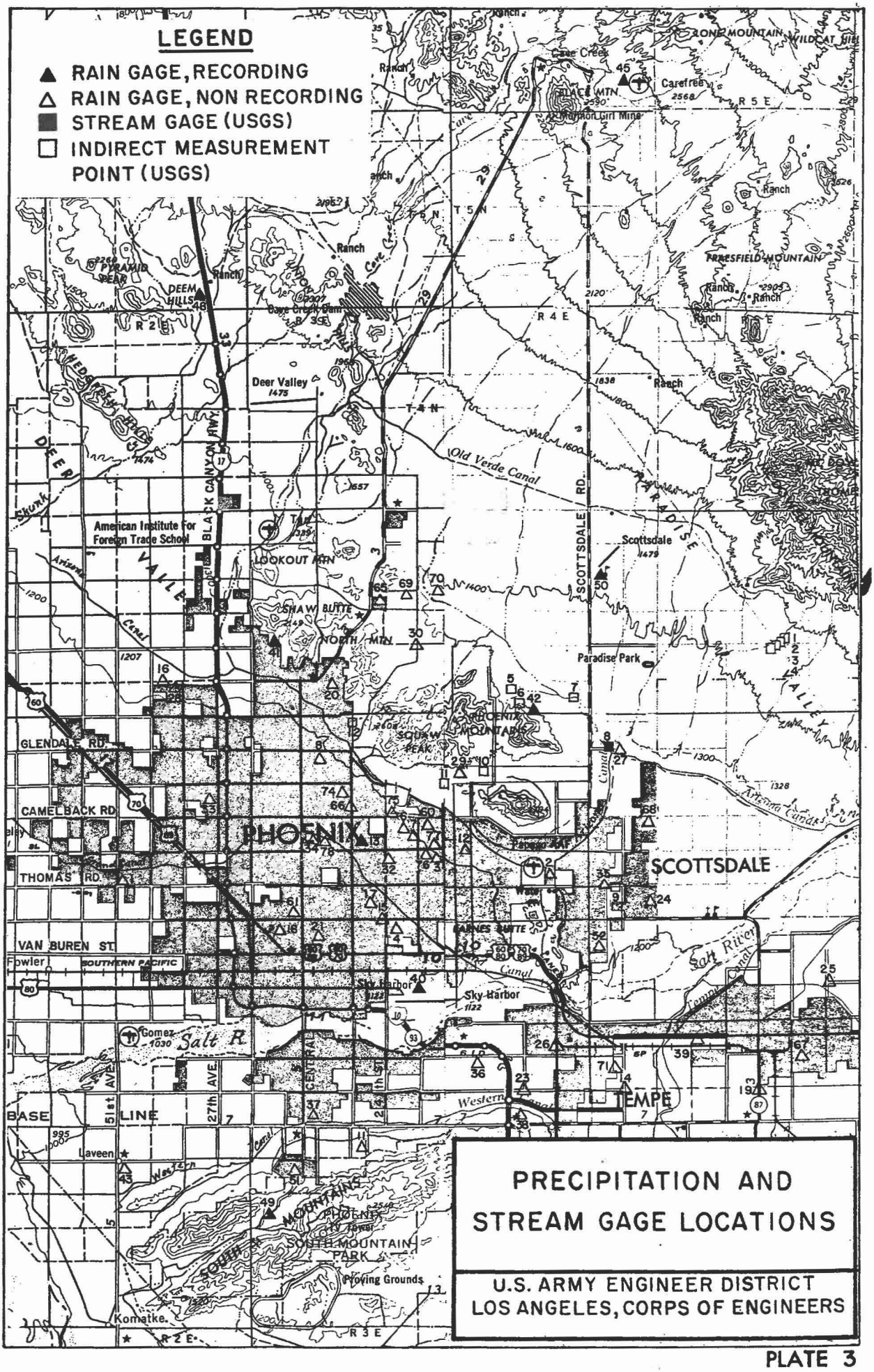
ISOHYETAL MAP

STORM OF 22 JUNE 1972

6 HOUR DURATION

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

PLATE 2



PRECIPITATION AND STREAM GAGE LOCATIONS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

PLATE 3

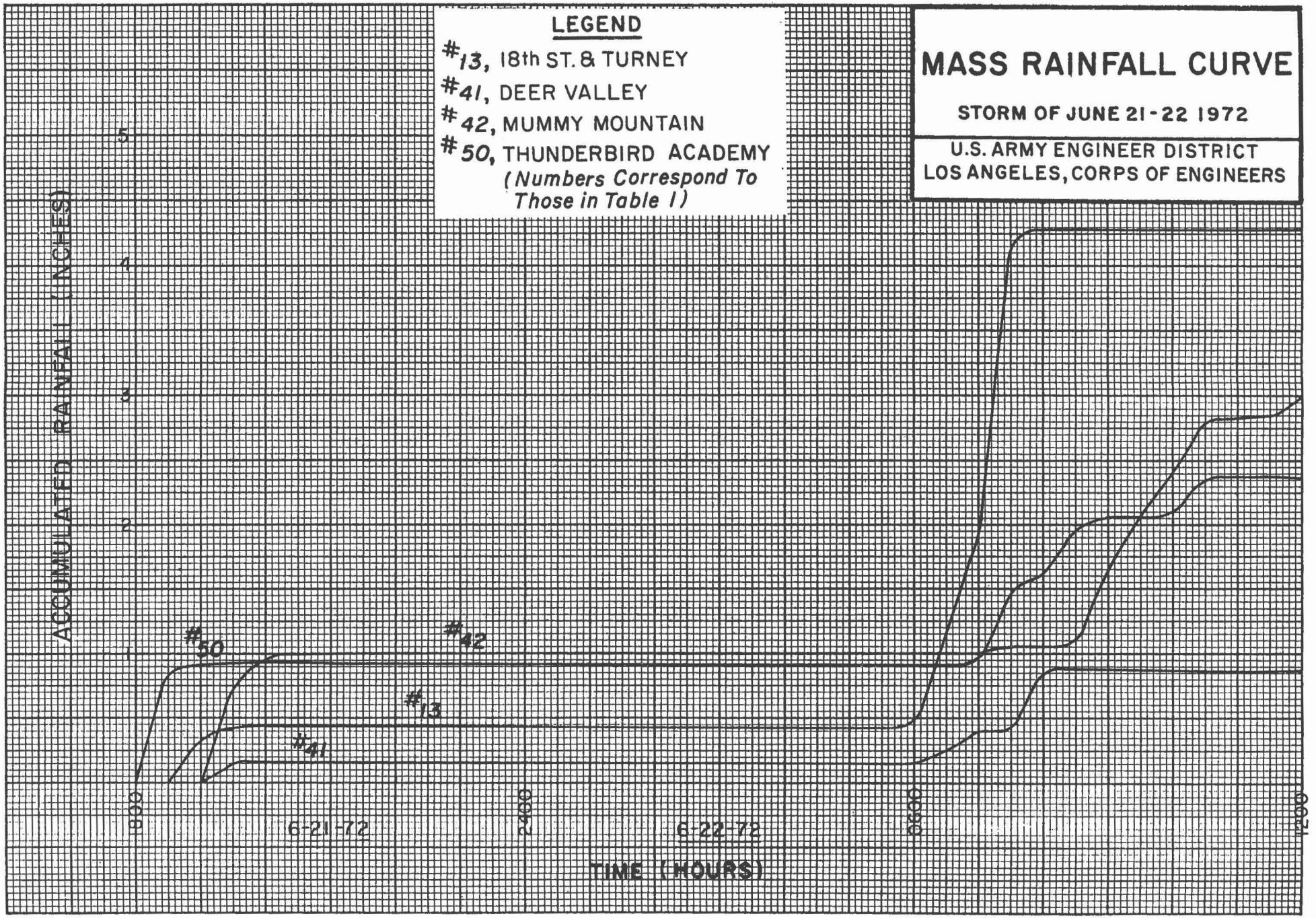

LEGEND
#13, 18th ST. & TURNEY
#41, DEER VALLEY
#42, MUMMY MOUNTAIN
#50, THUNDERBIRD ACADEMY
(Numbers Correspond To Those in Table 1)
MASS RAINFALL CURVE
STORM OF JUNE 21-22 1972
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
ACCUMULATED RAINFALL (INCHES)
5
4
3
2
#50
#42
#13
#41
1800
6-21-72
2400
6-22-72
0600
1200
TIME (HOURS)

PLATE 4

INDIAN BEND WASH

FLOOD HYDROGRAPH AT STREAMGAGE AT INDIAN BEND ROAD

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

NOTE: FLOOD HYDROGRAPH SHOWN WAS BASED ON DEPTH-DISCHARGE RATING CURVE FOR INDIAN BEND WASH AT INDIAN BEND ROAD AND A CHART OF GAGE HEIGHT VS. TIME FOR THE STREAMGAGE AT INDIAN BEND ROAD SUPPLIED BY THE USGS.

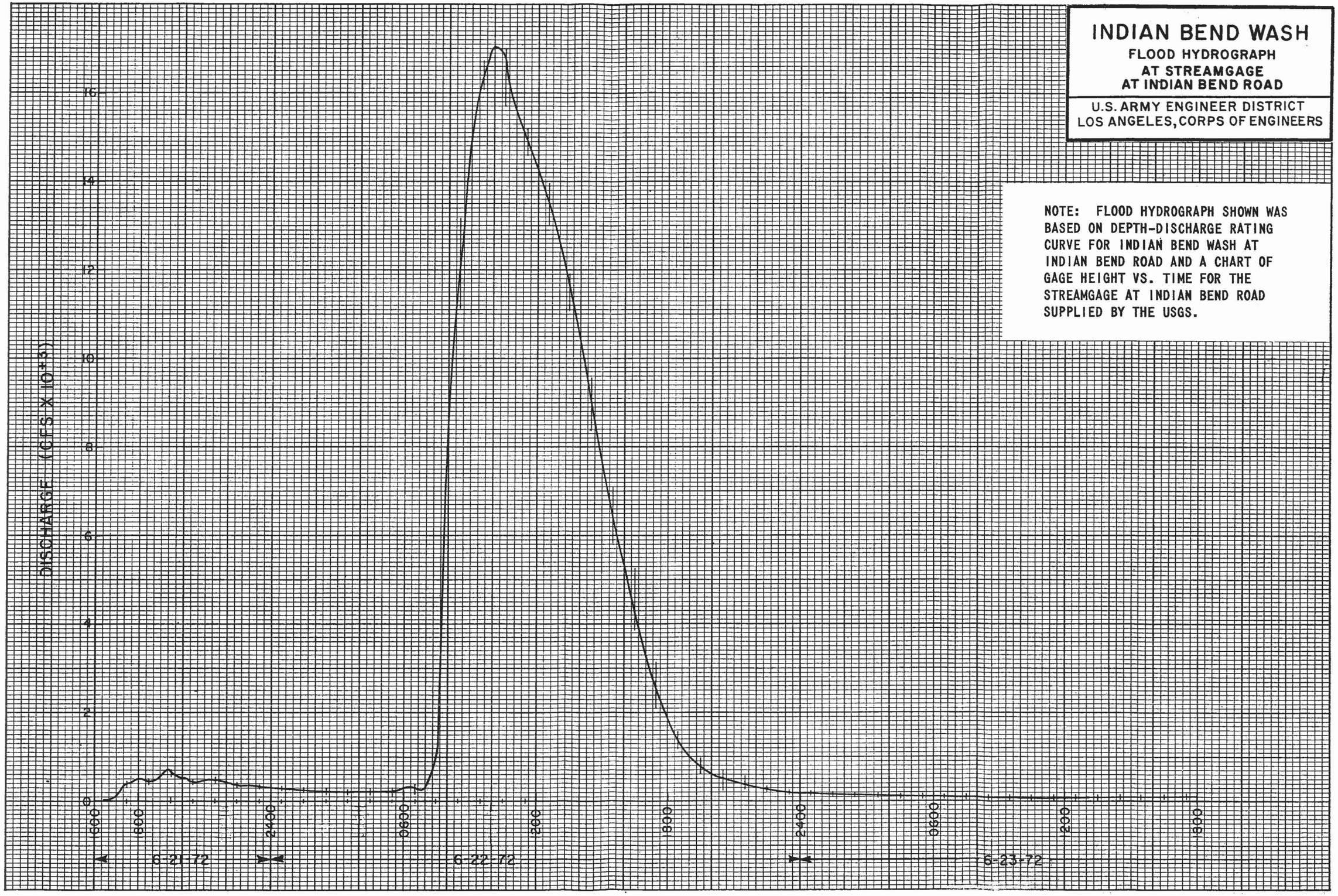


PLATE 5

ENVELOPING CURVE OF PEAK DISCHARGE

STREAMS IN THE PHOENIX AREA

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

(Numbers Correspond To Those in Table 3)

DISCHARGE IN CFS PER SQ. MI.

10,000 9 8 7 6 5 4 3 2 1,000 9 8 7 6 5 4 3 2 100 9 8 7 6 5 4 3 2 10

1 2 3 4 5 6 7 8 9 10 2 3 4 5 6 7 8 9 10 2 3 4 5 6 7 8 9 10 2 3 4 5 6 7 8 9 10 2 3 4 5 6 7 8 9 10

.01 .1 1 10 100 1000

DRAINAGE AREA IN SQ. MI.

PLATE 6

K+E LOGARITHMIC 359-120
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 X 3 CYCLES

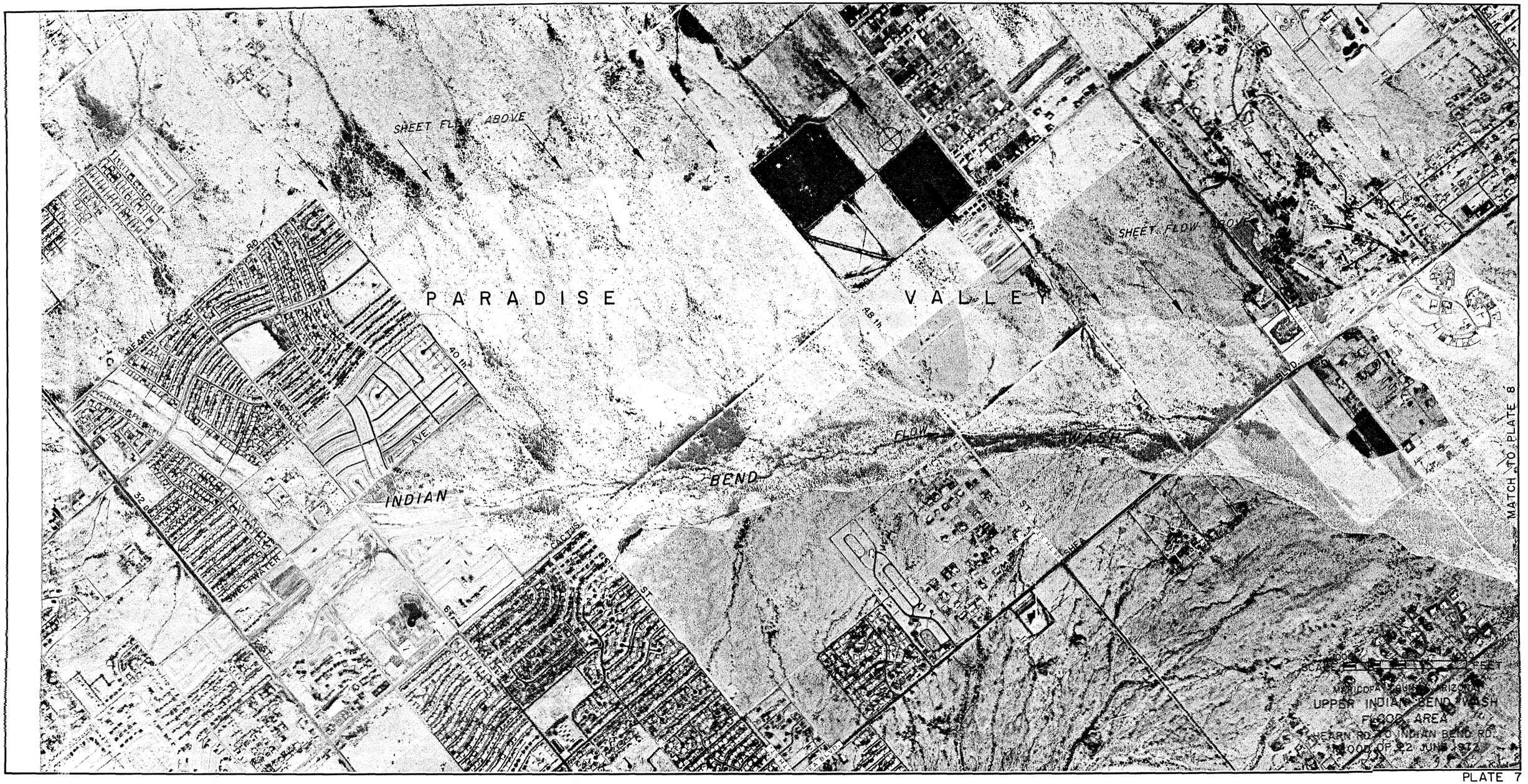

SHEET FLOW ABOVE
SHEET FLOW ABOVE
PARADISE
VALLEY
INDIAN
BEND
WASH
FLOW
MCDONALD DR.
40 th
48 th
32 nd
64th
CACTUS
ST
AVE
BLVD
MATCH TO PLATE 8
SCALE
FEET
MARICOPA COUNTY, ARIZONA
UPPER INDIAN BEND WASH
FLOOD AREA
MCDONALD DR. TO INDIAN BEND RD.
FLOOD OF 22 JUNE 1972

PLATE 7

MARICOPA COUNTY, ARIZONA

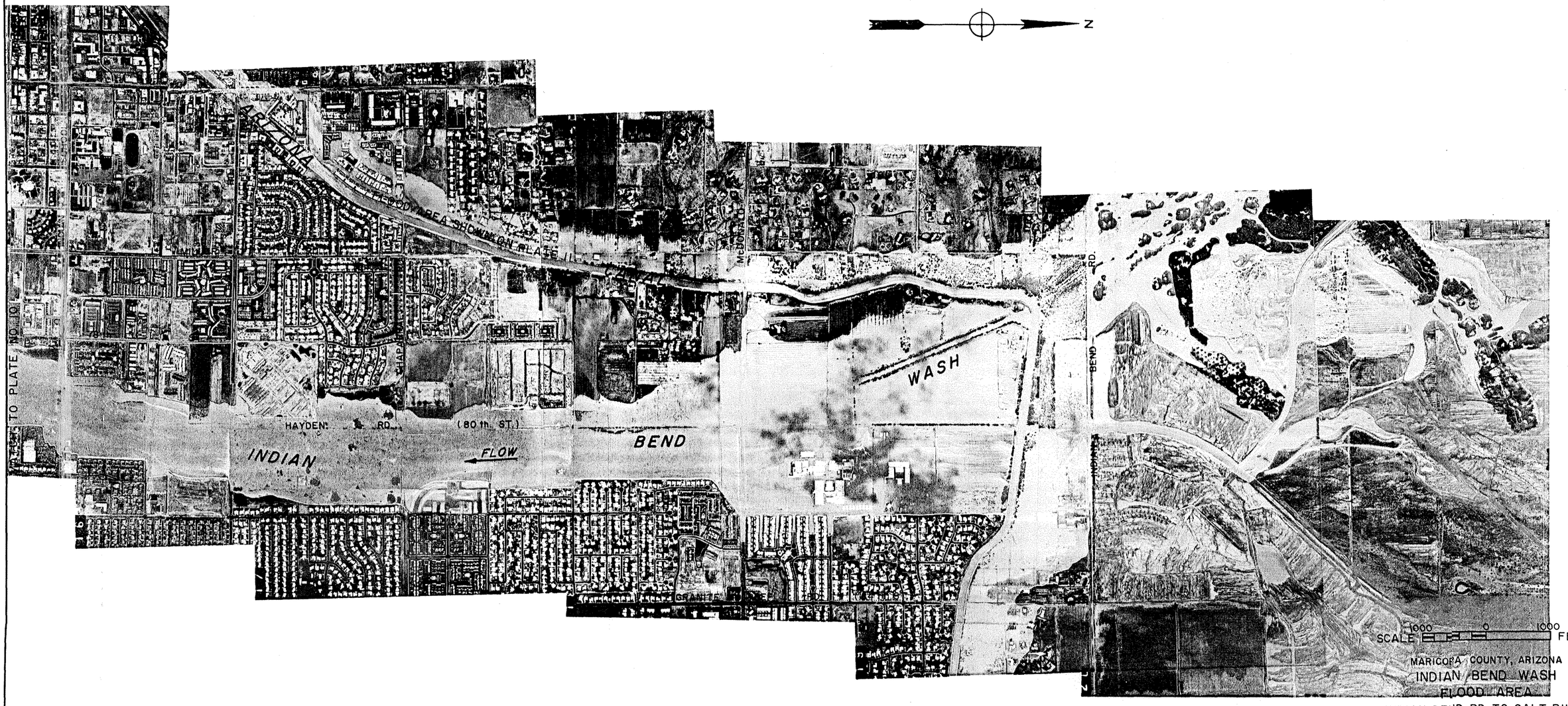
UPPER INDIAN BEND WASH

FLOOD AREA

HEARN RD. TO INDIAN BEND RD.

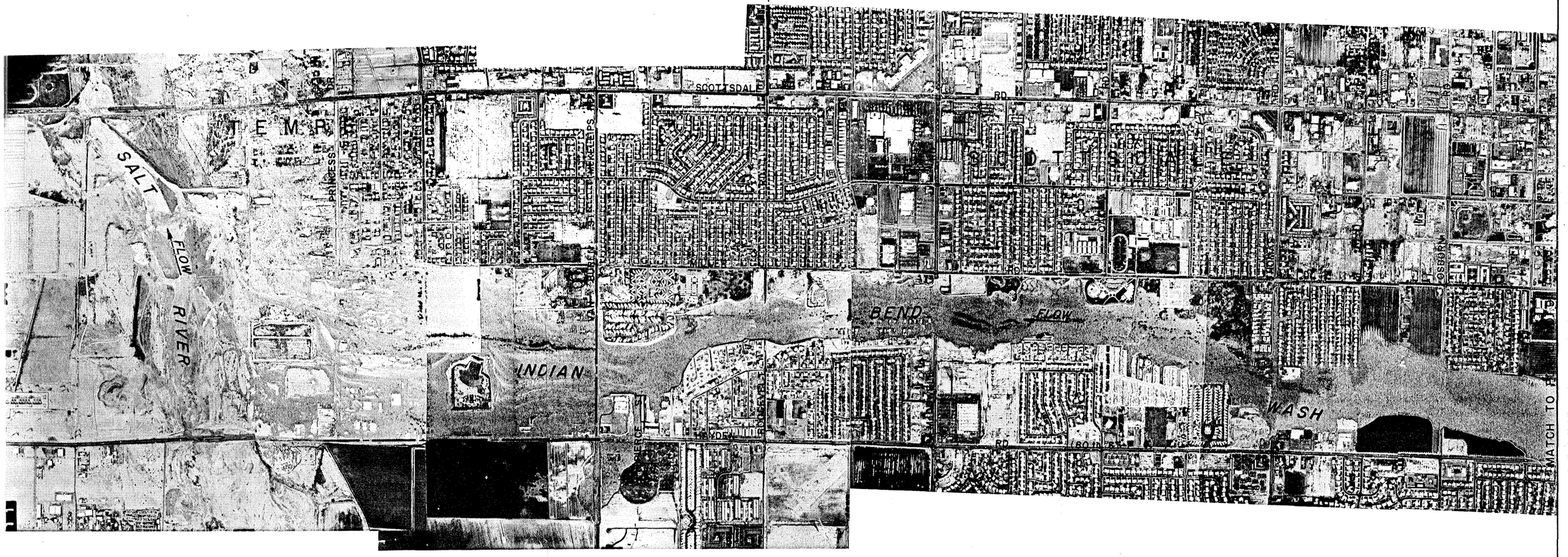
FLOOD OF 22 JUNE 1972

PLATE 8



MARICOPA COUNTY, ARIZONA
INDIAN BEND WASH
FLOOD AREA
INDIAN BEND RD. TO SALT RIVER
FLOOD OF 22 JUNE 1972

PLATE 9

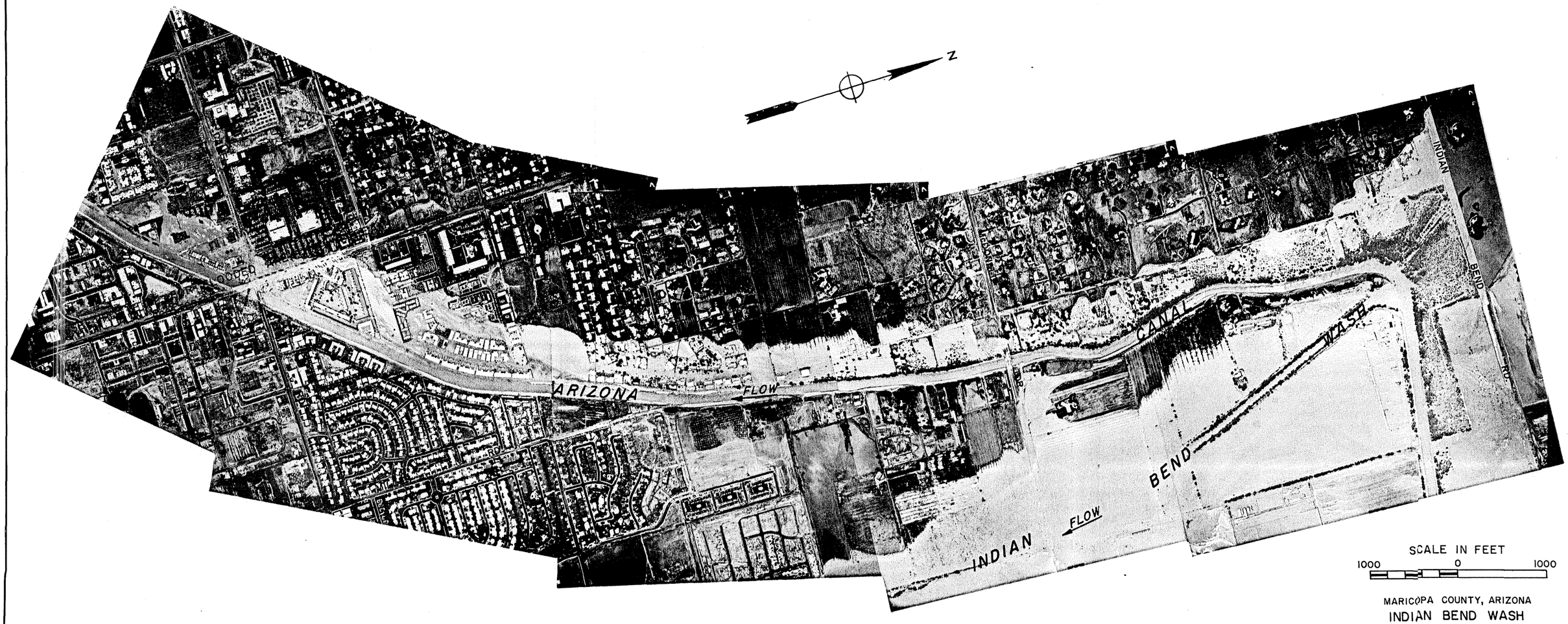


N

SCALE 1000 0 1000 FEET

MARICOPA COUNTY, ARIZONA
INDIAN BEND WASH
FLOOD AREA
INDIAN BEND RD. TO SALT RIVER
FLOOD OF 22 JUNE 1972

PLATE 10



SCALE IN FEET

1000 0 1000

MARICOPA COUNTY, ARIZONA

INDIAN BEND WASH

FLOOD AREA

ALONG ARIZONA CANAL FROM

INDIAN BEND RD. TO SCOTTSDALE RD.

FLOOD OF 22 JUNE 1972

PLATE II

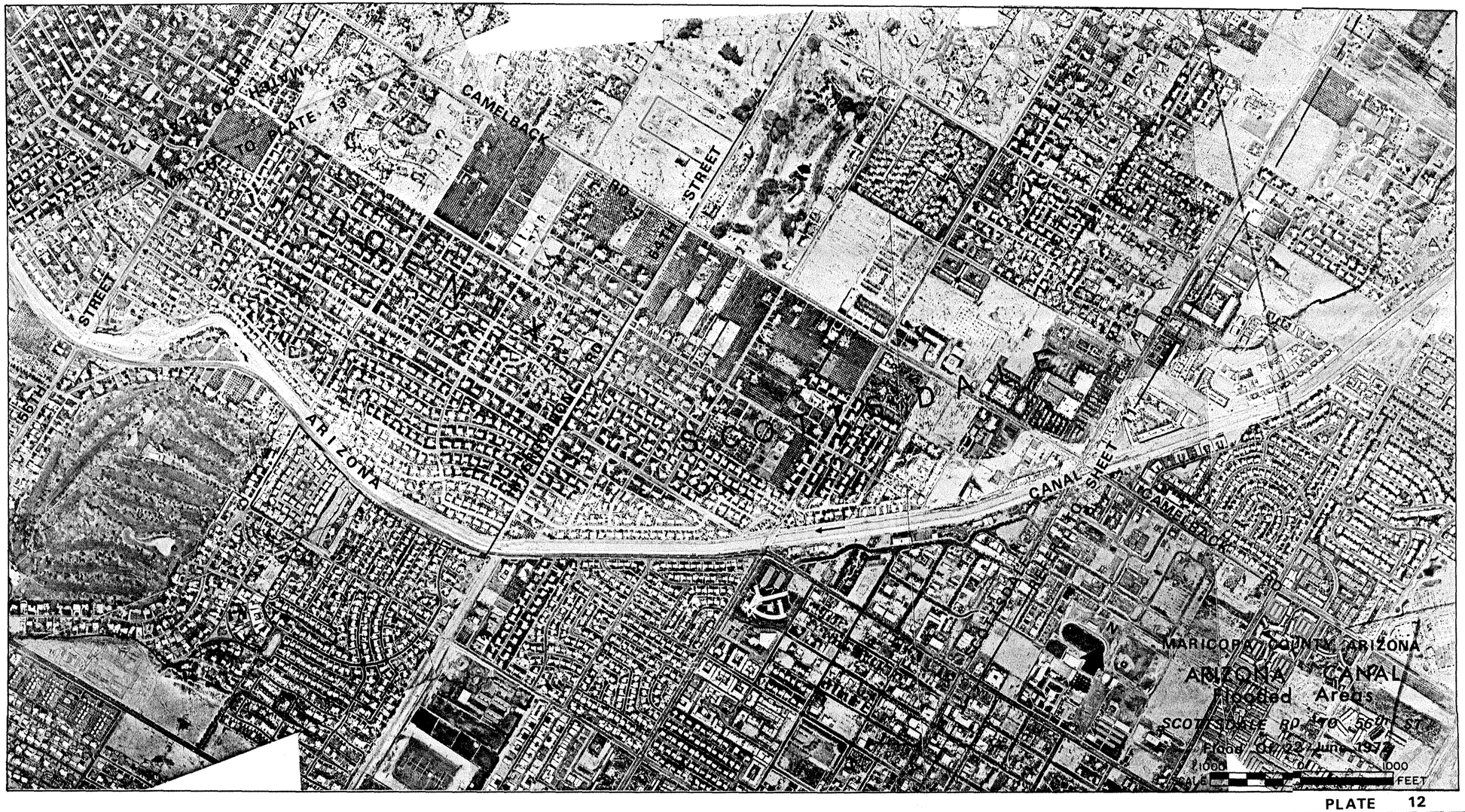
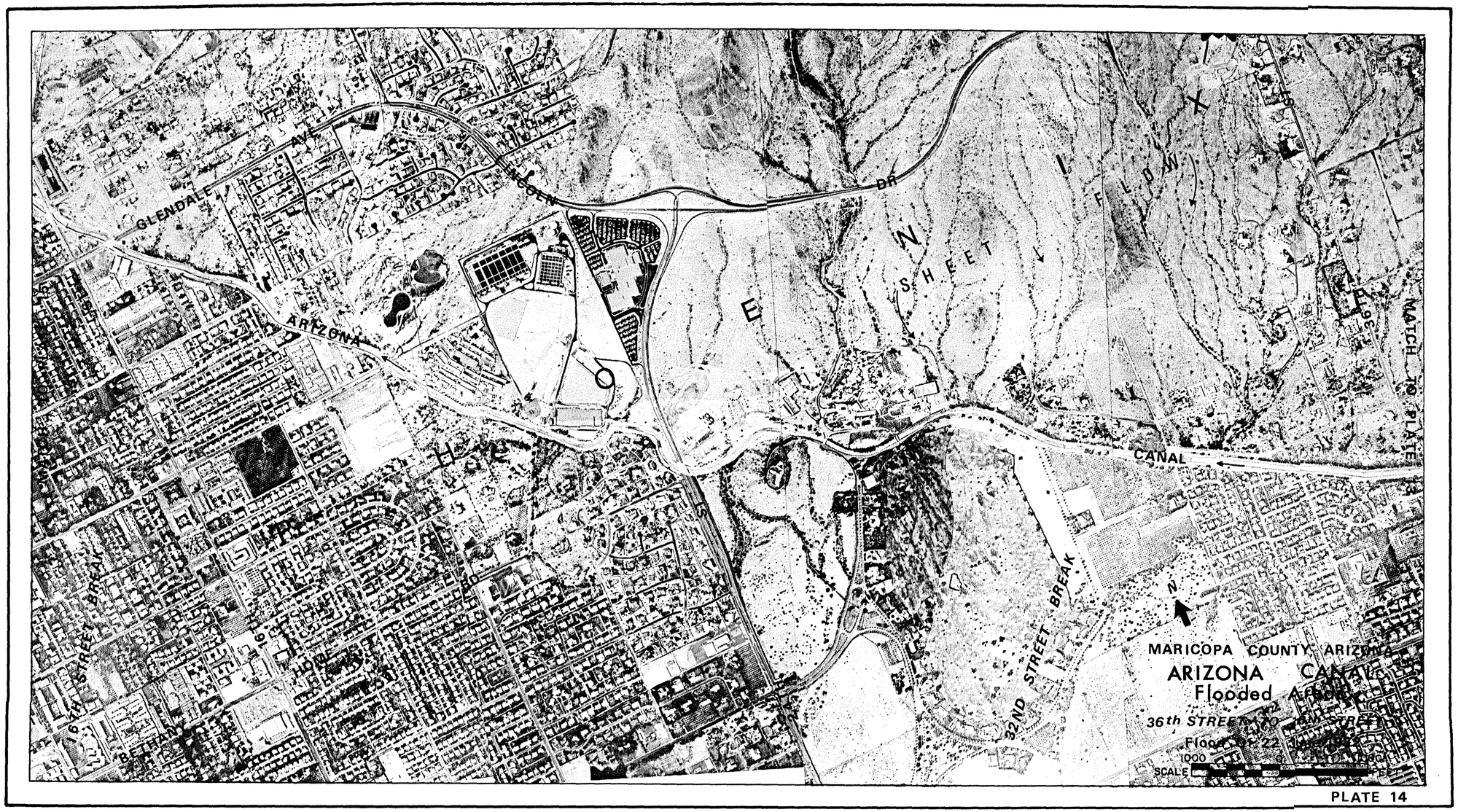

CAMELBACK
STREET
ARIZONA
CANAL
SHEET
FLOOD
CAMELBACK RD
MARICOPA COUNTY, ARIZONA
ARIZONA CANAL
Flooded Areas
SCOTTSDALE RD TO 56TH ST
Flood of 22 June 1972
SCALE
1000
0
1000
FEET

PLATE 12

CAMELBACK
RD
ARIZONA
CANAL
CAMELBACK
BREAKS
MATCH TO PLATE 14

PLATE 13


GLENDALE AV
LINCOLN DR
ARIZONA AV
CAMELBACK RD
16TH STREET BREAK
BETHANY HOME RD
32ND STREET BREAK
CANAL
SEE INDEX SHEET
MATCH LINE (PLATE 13)
N
MARICOPA COUNTY, ARIZONA
ARIZONA CANAL
Flooded Area
36th STREET TO 16th STREET
Flood of 22
1000
SCALE
PLATE 14

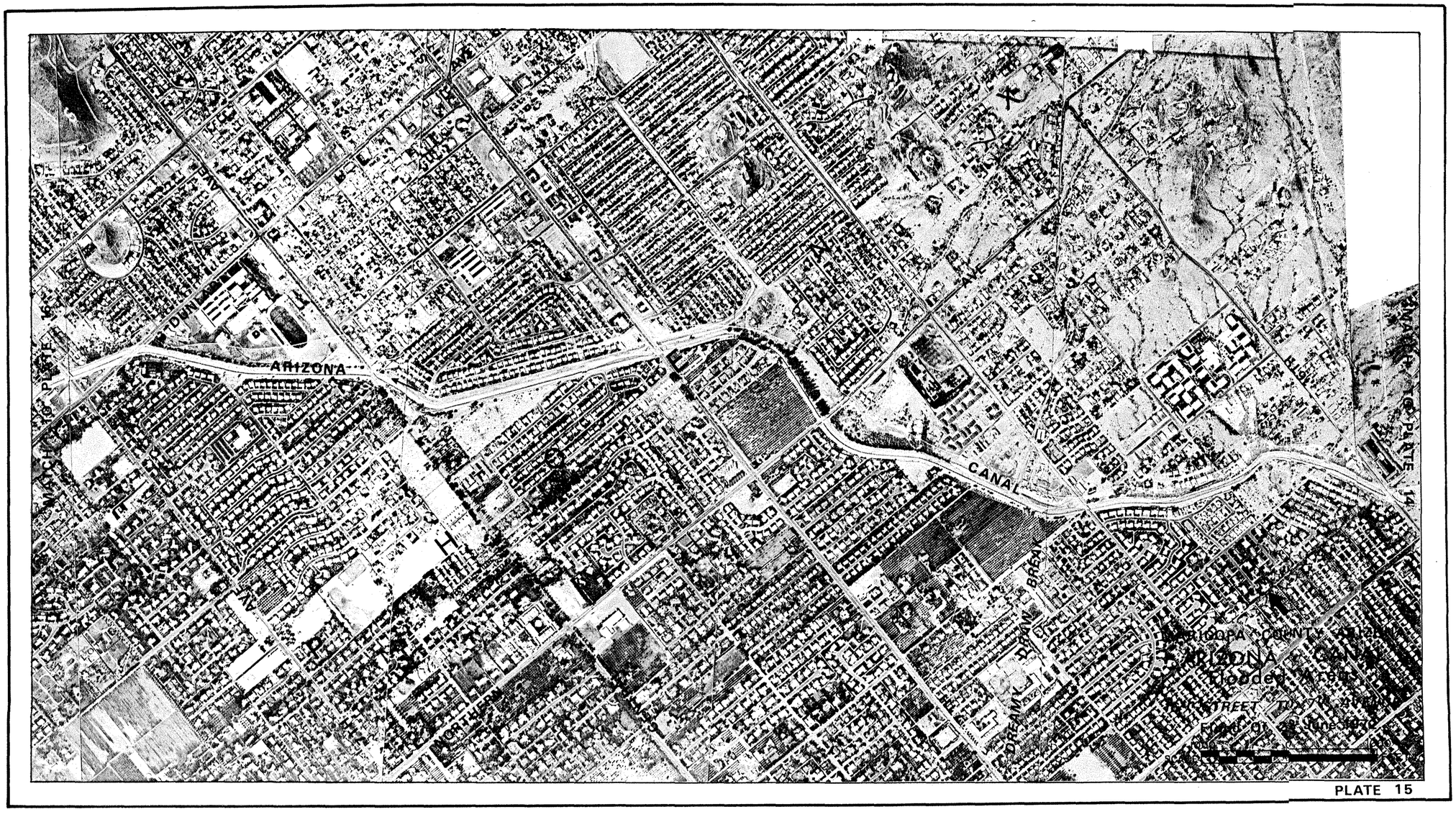


PLATE 15

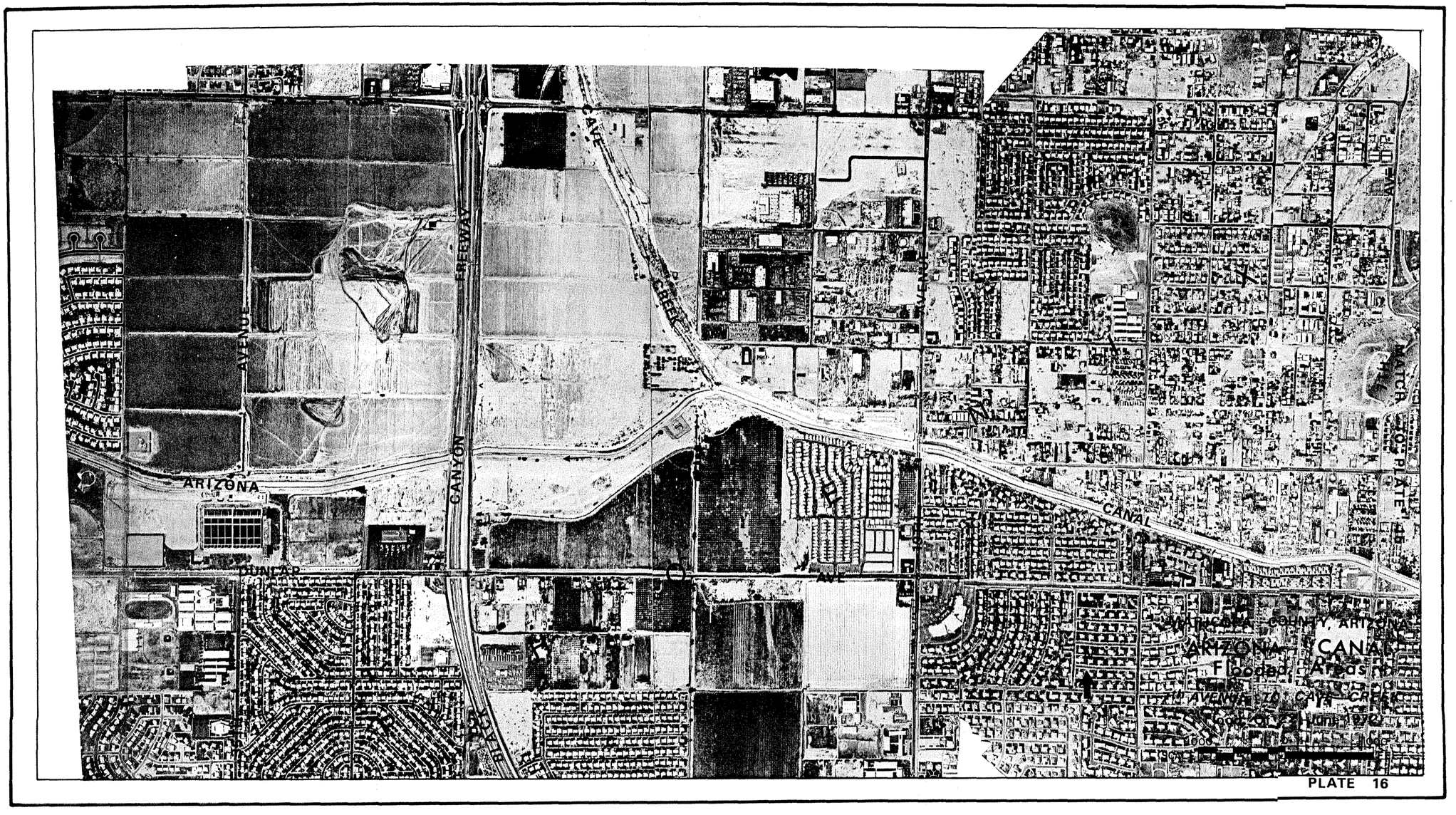

AVENUE
FREEWAY
CAVE
CREEK
AVENUE
MATCH LINE PLATE
ARIZONA
CANAL
GUNLAP
MARICOPA COUNTY, ARIZONA
ARIZONA CANAL
Flooded Areas in
the AVENUE 20 CAVE CREEK
Flood of June 1972
1000
1000

PLATE 16

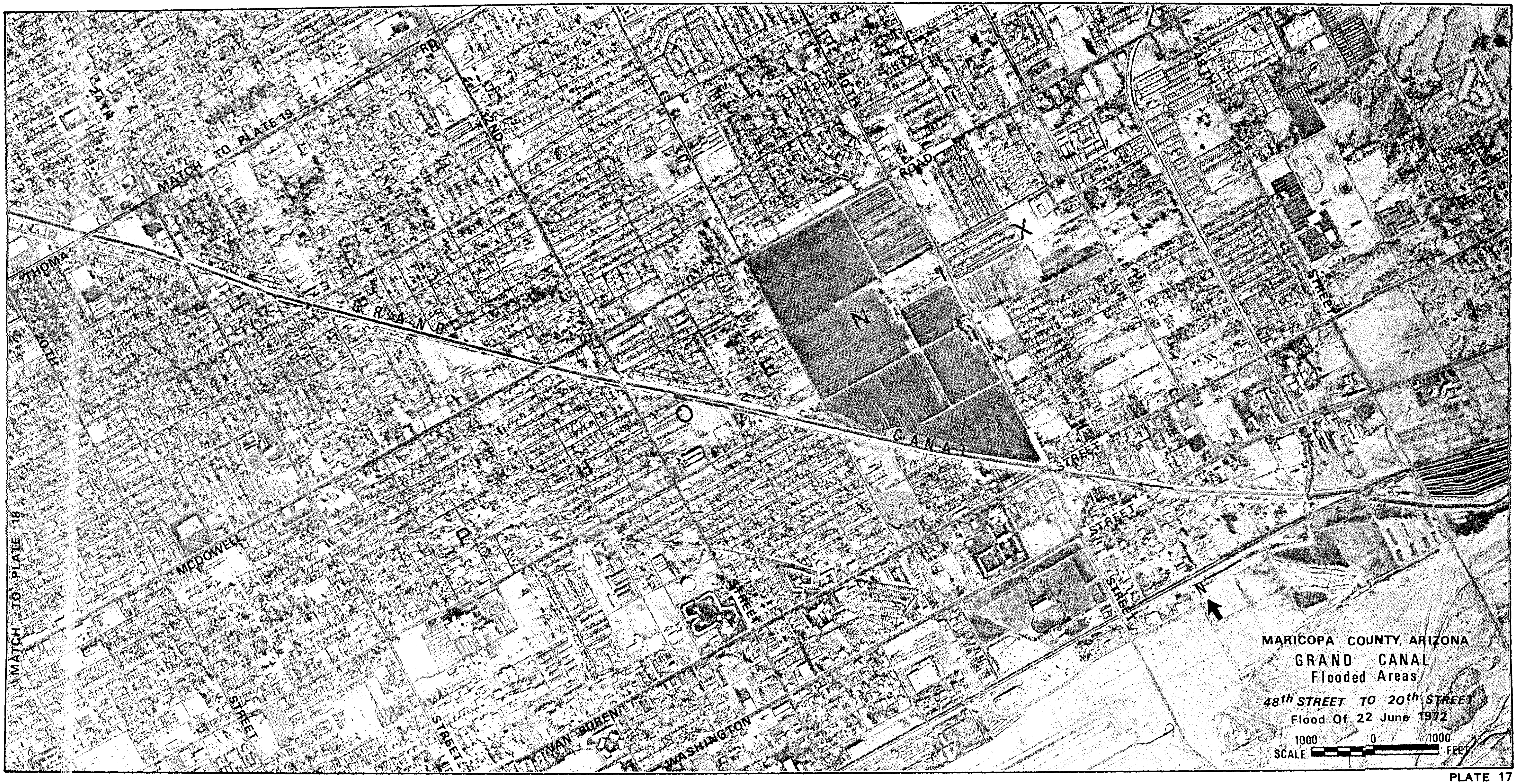

MATCH TO PLATE 19
THOMAS
24TH
RD
32ND
40TH
ROAD
48TH
STREET
GRAND
CANAL
STREET
STREET
STREET
MCDOWELL
20TH
MATCH TO PLATE 18
STREET
STREET
VAN BUREN
WASHINGTON
STREET
N
MARICOPA COUNTY, ARIZONA
GRAND CANAL
Flooded Areas
48th STREET TO 20th STREET
Flood Of 22 June 1972
1000 0 1000
SCALE FEET

PLATE 17

MATCH TO PLATE 19
CENTRAL AVE BRKW
12TH AVE BRKW
CENTRAL AVE
16TH STREET
20TH STREET
ROAD
INDIAN SCHOOL ROAD
OSBORN ROAD
THOMAS AVENUE
MARICOPA COUNTY, ARIZONA
GRAND CANAL
Flooded Areas
20th STREET TO 19th AVENUE
Flood Of 22 June 1972
SCALE 1000 0 1000 FEET

PLATE 18

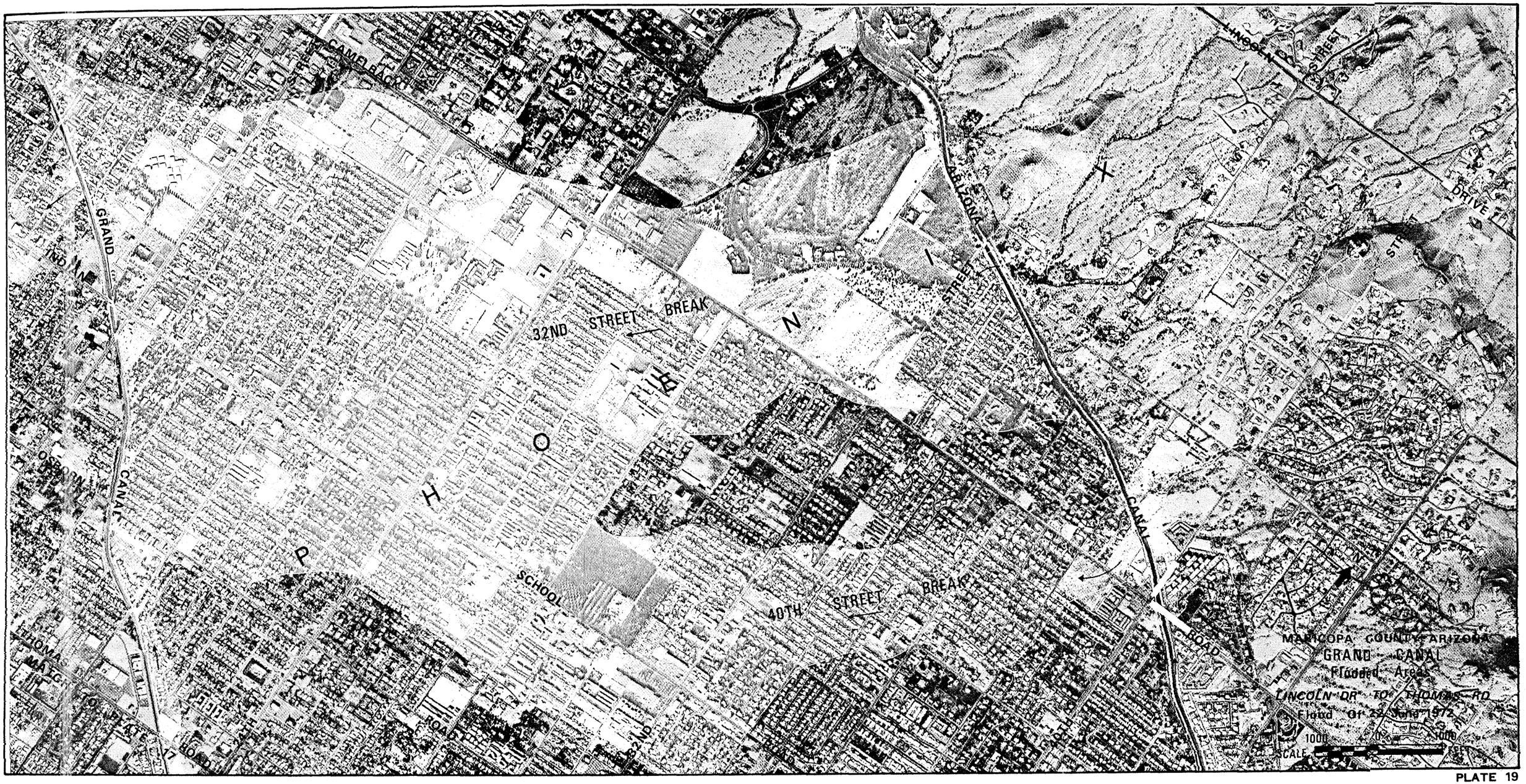

CAMELBACK
GRAND
CANAL
OSBORN
THOMAS
ROAD
PLATE 17
32ND STREET BREAK
32ND STREET
SCHOOL
40TH STREET BREAK
40TH STREET
ARIZONA
CANAL
LINCOLN
DRIVE
MARICOPA COUNTY, ARIZONA
GRAND CANAL
Flooded Areas
LINCOLN DR. TO THOMAS RD.
Flood Of 22 June 1972
SCALE
1000
0
1000
FEET

PLATE 19

DRAFT REPORT

STORM DRAINAGE AND FLOOD CONTROL STUDY SOUTHEASTERN MARICOPA COUNTY STATE OF ARIZONA

MAY 1973

PREPARED FOR
MARICOPA COUNTY

BY
BOYLE ENGINEERING CORPORATION
AND
L. H. BELL AND ASSOCIATES
A JOINT VENTURE

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STORM DRAINAGE AND FLOOD CONTROL STUDY
SOUTHEASTERN MARICOPA COUNTY

INTRODUCTION

This storm drainage and flood control study of southeastern Maricopa County has been prepared to bring into focus the problems related to storm runoff and the needs for measures to control this runoff under conditions of present development and in anticipation of projected future development in this area.

There have been a number of previous studies and investigations related to the control of storm runoff in this area. The Flood Control District of Maricopa County has sponsored the development of projects by federal agencies and has made overall studies of the area's problems and recommended solutions.

There has been considerable progress toward the solution of the major problems in the area. Federally assisted projects have been installed and other projects have been approved for construction and could be installed within the next several years which would provide protection to the major developed areas from potentially disastrous floods.

It is the objective of the present study to evaluate previous studies, make additional investigations and recommend a program for the solution of the storm runoff problems in this area.

The development of concepts for additional projects within the study area is based generally upon available information. The intensity of planning has been limited to that required to determine the engineering feasibility of the concepts and to determine approximate dimensions of the costs for alternatives that would provide solutions to the storm runoff problems. A hydrologic analysis was made for the area west of the Roosevelt Water Conservation District Canal in accordance with procedures and criteria used by the Soil Conservation Service in formulating their Public Law 566 watershed projects in the area.

These additional projects have been formulated to include structural measures with capacities to contain the estimated 100-year return period peak flood flows. These capacities are intended to approximate those that would be provided in flood control projects designed and installed with federal agency assistance. Structural measures with smaller capacities may be installed to provide protection against the more frequently occurring floods as an interim measure or as a necessary expedient.

DESCRIPTION OF THE STUDY AREA

The study area generally includes the drainage area bounded on the east by the Superstition Mountains; on the north by the Salt River drainage area boundary; on the west by the extent of the area draining into the Gila Drain; and on the south by Queen Creek and the Gila River.

The major portion of the area is in agricultural use and even though urban development is rapidly expanding much of the area will remain in agriculture

for the foreseeable future. The principal cities and towns in the area are Mesa, Chandler and Gilbert with Tempe progressively expanding into the area.

Irrigation water supply for agriculture is provided by the Salt River Project, the Roosevelt Water Conservation District, the Queen Creek Irrigation District and the Chandler Heights Citrus Irrigation District. The Salt River Project provides the major source of irrigation water supply within the area, including all irrigated agricultural lands to the west and to Eastern Canal on the east. Other major Salt River Project canals in the area are the Consolidated Canal located west of the Eastern Canal, Tempe Canal which is the dividing line between the cities of Tempe and Mesa, and Western Canal which runs in an east-west direction from the Consolidated Canal through the north edge of Gilbert to discharge into the Gila Drain.

The Roosevelt Water Conservation District Canal is located east of the Eastern Canal and provides irrigation water supply to an area east of that served by the Salt River Project.

The Queen Creek Irrigation District is comprised of lands located adjacent to Queen Creek above the Consolidated and Eastern Canals. The Chandler Heights Citrus Irrigation District provides irrigation water supply to the area in the vicinity of Chandler Heights. Both of these irrigation districts obtain their water supply from wells.

The total drainage area above the Roosevelt Water Conservation District Canal and the considered floodway through the Gila Indian Reservation, including the Queen Creek drainage area, is 759 square miles. The additional drainage area below the Roosevelt Water Conservation District canal, which drains into the Gila Drain on the west side of the study area, is 244 square miles.

The estimated present population in southeastern Maricopa County, including the City of Tempe, is in excess of 200,000. It is projected that the population in this area will increase to about 600,000 by the year 1990. The cities of Tempe and Mesa have populations of 85,000 and 80,250, respectively, at the present time.

The storm drainage and flood problems in this area have become progressively more serious as urban development has expanded. This is due to the reduced infiltration rates that result from urban development as compared to agricultural use of the land and the concentrations of runoff into larger channelized flows, which increase the potential for damages. Such development as the Superstition Freeway which requires concentrations of storm runoff for freeway crossings typify this problem.

During the period 1910 through 1971 a total of 38 floods have been reported. Many of these storms, which caused relatively minor damages in the past under conditions of agricultural land use, would cause much greater damages under present conditions of urban development, because of the larger amounts of runoff that would occur and the greater damage potential. This condition will become progressively more serious as urban development continues to expand.

The runoff from the drainage areas above the irrigation water supply canals is intercepted by these canals. When the intercepted runoff exceeds the limited capacities of these canals, they are breached and the large flows cause damages to the lower lands and cause breaching of the lower canals. Surface runoff into the canals also causes large maintenance costs to remove debris accumulation.

The most vulnerable of these canals is the Roosevelt Water Conservation District Canal which has the largest drainage area above it. In order to protect the canal from damages caused by runoff, the District has constructed an

interception floodway above the canal which they have enlarged progressively over the years. At the present time the floodway does not have adequate capacity to contain a major flood and there is no controlled outlet for the accumulated flows.

The Eastern and Consolidated canals have similar problems to those of the Roosevelt Water Conservation District canal, even though the drainage areas above them are smaller. They have some intercepting floodway capacities above them which are inadequate for major floods and there are no controlled outlets for this intercepted runoff. In the event that the Roosevelt Water Conservation District Canal was breached, the Eastern and Consolidated Canals would be severely damaged by the released flow.

PROJECTS PLANNED FOR INSTALLATION

The Soil Conservation Service has prepared three watershed work plans under provisions of Public Law 566, as amended, to control the flood flows from the east to the Roosevelt Water Conservation District Canal. These work plans include floodwater retarding structures, diversion structures and floodways to provide protection against the 100-year return period flood. All of these work plans have been approved for construction and are currently being amended to provide additional capacities in a floodway adjacent to and above the Roosevelt Water Conservation District Canal and to provide an outlet for the floodway through the Gila Indian Reservation to the Gila River.

The floodwater retarding and diversion structures are generally located immediately above the alignment for the Central Arizona Project Canal anticipated to be installed within the next 10 years. These measures will provide protection to this canal from flood and debris damages.

Some of the structural measures included in these work plans have been installed and the remaining measures may be installed when provisions are made to meet other costs than those that are funded under provisions of Public Law 566 and as Public Law 566 funds are available.

These structural measures are included in the following Public Law 566 watershed projects:

Buckhorn-Mesa Watershed Project. This project includes floodwater retarding structures, a diversion and floodways as tabulated on Table 1 . These measures will provide for the diversion and retarding of flood flows above the Central Arizona Project Canal alignment from the Salt River to Apache Trail. The present plan provides for the diversion of the controlled flows into the Salt River. It is anticipated that the plan will be revised to divert

TABLE 1
ESTIMATED INSTALLATION COSTS
BUCKHORN - MESA P.L.566 PROJECT

PROJECT MEASURES	PROJECT COSTS - (DOLLARS) TOTAL P.L.566	TOTAL OTHER	MEASURES INSTALLED P.L.566	MEASURES INSTALLED OTHER	REMAINING P.L.566	REMAINING OTHER
Floodwater Retarding Structures:						
Spook Hill	974,400 1/	1,759,500 2/			974,400 1/	1,759,500 2/
Signal Butte	486,000 3/	148,000 4/			486,000 3/	148,000 4/
Apache Junction	474,200 3/	156,800 5/			474,200 3/	156,800 5/
Pass Mountain	245,000 3/	0 6/			245,000 3/	0 6/
Bulldog Diversion	124,800 3/	36,800 7/			124,800 3/	36,800 7/
Floodways:						
Spook Hill	723,200 1/ 3/	168,300 8/ 9/			723,200 1/ 3/	168,300 8/ 9/
Signal Butte	513,600 3/	142,500 10/			513,600 3/	142,500 10/
Apache Junction	326,000 3/	3,500 11/			326,000 3/	3,500 11/
Pass Mountain	148,200 3/	9,600 11/			148,200 3/	9,600 11/
RWCD-Hwy. to Brown Rd. 13/	150,000	750,000 12/			150,000	750.000 12/
	4,165,400	3,175,000			4,165,400	3,175,000

1/ 1963 Prices x 1.2 (inf. factor)
2/ 1963 Prices x 1.5 (inf. factor): 3 bridges - $45,000 (total); relocate transmission line - $7,500; serverance - $15,000; 449 ac. land @ $3,750 - $1,683,000; and admin. contracts - $9,000.
3/ 1963 Prices x 1.2 (inf. factor) - Revised plan and costs.
4/ 185 acres state land @ $800 per acre (assumed); no road crossings or utility relocations.
5/ 196 acres state land @ $800 per acre (assumed); no road crossings or utility relocations.
6/ 70 acres land in Usury Park required; no road crossings or utility relocations.
7/ 46 acres state land @ $800 per acre (assumed); no road crossings or utility relocations.
8/ 1963 prices x 1.5 (inf. factor): 1 bridge - $21,000; 41 ac. land @ $3,400 - $139,500; R/W for debris basin 7.9 ac. - $600 (total); and admin. of contracts - $7,200.
9/ 1963 prices x 1.5 (inf. factor): 2 bridges - $33,750; 29 acres land @ $3,750 - $108,750.
10/ Wilson road crossing - $2,100; 3 ac. state land @ $2,400 (assumed).
11/ Road crossing - $2,100; 2 ac. state land @ $800 - $1,600; and 2 ac. private land - @ $2,950 - $5,900.
12/ Land for R/W - $150,000; and two bridges - $600,000.
13/ Supplemental Work Plan now being prepared to extend the RWCD Floodway from Hwy. 80 to Brown Road and to relocate three of the floodwater retarding structures onto State and Federal lands. The Bureau of Reclamation has made a tentative commitment to participate in the purchase of rights-of-way to the extent that the project benefits the Central Arizona Project.

these flows into Orme Reservoir, which will be constructed as an element of the Central Arizona Project. The work plan is also being amended to extend the Roosevelt Water Conservation District floodway from Apache Trail to Brown Road. The estimated installation costs as shown on Table 1 include the costs for extending the floodway. None of these measures have been installed.

Apache Junction-Gilbert Watershed Project. This project provides for the control of flood flows above the Central Arizona Project Canal alignment from Apache Trail to Ray Road. It includes a floodwater retarding structure and a floodway to discharge the controlled flows from this structure and the floodwater retarding structures included in the Williams-Chandler Watershed Project to the Roosevelt Water Conservation District floodway. It also includes the enlargement of the existing Roosevelt Water Conservation District floodway to provide capacities for the estimated 100-year return period flood from Apache Trail to Ray Road.

The floodwater retarding structure and the floodway from this structure to the Roosevelt Water Conservation District floodway have been installed. The enlargement of the Roosevelt Water Conservation District floodway remains to be done. Table 2 shows the costs of the structural measures that have been installed and the estimated costs to enlarge the Roosevelt Water Conservation District floodway.

Williams-Chandler Watershed Project. This project provides for the control of flood flows above the Central Arizona Project Canal alignment from Ray Road to the boundary of the drainage area into Queen Creek. It includes two floodwater retarding structures which discharge their controlled flood flows through the floodway included in the Apache Junction-Gilbert Watershed

TABLE 2
ESTIMATED INSTALLATION COSTS
APACHE JUNCTION - GILBERT P.L.566 PROJECT

PROJECT MEASURES	PROJECT COSTS - (DOLLARS) TOTAL P.L.566	TOTAL OTHER	MEASURES INSTALLED P.L.566	MEASURES INSTALLED OTHER	REMAINING P.L.566	REMAINING OTHER
Powerline FWR Structure	1,498,000	31,210	1,498,000	31,210 1/		
Diversion Structure & Floodway (Actual value of donated state land)				(798,000)		
Floodways:						
RWCD - Apache Trail to Ray Road	500,000	1,400,000 1/			500,000	1,400,000
	1,998,000	1,431,210	1,498,000	31,210	500,000	1,400,000

1/ Actual Costs Incurred

2/ 7 bridges @ $100,000 = $700,000; 233 acres land @ $3,000 = $700,000

Project to the Roosevelt Water Conservation District floodway. It also includes the enlargement of the existing Roosevelt Water Conservation District floodway to contain the estimated 100-year return period flood flows from Ray Road to the junction with Queen Creek. The work plan for this project is being amended to provide an outlet for the Roosevelt Water Conservation District floodway from the junction with Queen Creek through the Gila Indian Reservation to the Gila River.

The floodwater retarding reservoirs have been installed. The enlargement of the Roosevelt Water Conservation District floodway remains to be done. Table 3 shows the costs of the structural measures that have been installed and the estimated cost to enlarge the Roosevelt Water Conservation District floodway and provide an outlet to the Gila River.

The Corps of Engineers has planned and installed Whitlow Dam and Reservoir on Queen Creek above its junction with Whitlow Canyon. This reservoir controls the flood flows from the major portion of the Queen Creek watershed.

An application for assistance under provisions of Public Law 566 was made to the Soil Conservation Service for a watershed project to provide additional control of floods from the Queen Creek watershed and the drainage area west of the Roosevelt Water Conservation District Canal which drains into the Gila Drain, which passes through the Gila Indian Reservation to the Gila River on the southwest side of the study area. The application was approved for planning to include the Queen Creek watershed only. Approval for planning the area for which the runoff discharges through the Gila Drain was withheld on the basis that the land use of a major portion of this area would change from agricultural use to urban use in the relatively near future. This would require a higher degree of protection than for agricultural land use and a major portion of the benefits

TABLE 3
ESTIMATED INSTALLATION COSTS
WILLIAMS - CHANDLER P.L.566 PROJECT

PROJECT MEASURES	PROJECT COSTS - (DOLLARS) TOTAL P.L.566	TOTAL OTHER	MEASURES INSTALLED P.L.566	MEASURES INSTALLED OTHER	REMAINING P.L.566	REMAINING OTHER
Floodwater Retarding Structures:						
Rittenhouse - Vineyard Road	1,130,000	522,330[1/]	1.130.000	62,330[1/]		460,000[1/]
Floodway:						
Roosevelt WCD[3/]	3,000,000	2,860,000[2/]			3,000,000	2,860,000[2/]
	4,130,000	3,382,330	1,130,000	62,330	3,000,000	3,320,000

1/ Actual costs to obtain government land - $62,330; Hwy. Bridge - $460,000 (budgeted but not spent. Actual value of land estimated at $2,040,000 (also shown at a reduced value of $1,040,000.

2/ 300 acres private lands @ $3,000 - $900,000; 2 bridges in Indian Reservation - $460,000; and 6 bridges outside Indian Reservation @ $250,000 - $ 1,500,000. Value of donated right-of-way in Indian Reservation - $600,000 (not included in total).

3/ Includes extension of RWCD Floodway through Indian Reservation. A Supplemental Work Plan is now being prepared to include this extension.

would have to be based on this projected urban development in order to obtain a favorable benefit-cost ratio. Projects obtaining federal assistance under provisions of Public Law 566 should provide agricultural benefits primarily. Where the benefits are based primarily on the protection of urban areas, federal assistance from the Corps of Engineers is considered more appropriate.

The Soil Conservation Service is currently preparing a watershed work plan for the Lower Queen Creek Project in accordance with the approved portion of the original application. This project will include a floodwater retarding reservoir with outlet works. Table 4 shows the very preliminary estimated costs for these structural measures.

With the installation of all of the structural measures included in the three Public Law 566 projects approved for construction, as supplemented and amended, and the measures anticipated to be included in the Lower Queen Creek Project, major flooding will be controlled from the entire area east of the Roosevelt Water Conservation District Canal and these flows will be provided with an outlet into the Gila River.

The Soil Conservation Service has prepared a watershed work plan under provisions of Public Law 566 for the Guadalupe watershed on the west side of the study area and immediately west of the community of Guadalupe and Freeway I-10. It has been approved for construction and procurement of rights-of-way is in process. This is a small watershed with a total drainage area of about 7.2 square miles. This project includes a floodwater retarding structure, a diversion structure and a pipeline to remove water from the floodwater retarding structure at a rate compatible with capacity limitations of the Western Canal. These measures will control the runoff from 1.87 square miles of watershed and their installation will provide flood protection to the community of Guadalupe

TABLE 4
ESTIMATED INSTALLATION COSTS (Reconnaissance only)
LOWER QUEEN CREEK P.L.566 PROJECT (Application approved for planning)

PROJECT MEASURES	PROJECT COSTS - (DOLLARS)[1/] TOTAL		MEASURES INSTALLED		REMAINING	
	P.L.566	OTHER	P.L.566	OTHER	P.L.566	OTHER
Lower Queen Creek Floodwater Retarding Reservoir	1,600,000	500,000[2/]			1,600,000	500,000[2/]
Reservoir Outlet	750,000	300,000[3/]			750,000	300,000[3/]
Total - Lower Queen Creek Project	2,350,000	800,000			2,350,000	800,000

1/ Very preliminary cost estimates.
2/ Land for right-of-way only.
3/ Land for right-of-way $250,000 (including land for groundwater recharge); and bridges - $50,000.

and Freeway 10. Table 5 shows the estimated installation costs for these structural measures.

TABLE 5
ESTIMATED INSTALLATION COSTS
GUADALUPE P.L.566 WATERSHED PROJECT

PROJECT MEASURES	TOTAL P.L.566	TOTAL OTHER 2/	PROJECT COSTS - (DOLLARS) MEASURES INSTALLED P.L.566	MEASURES INSTALLED OTHER	REMAINING P.L.566	REMAINING OTHER 2/
Floodwater Retarding Structure	186,940	266,160 2/			186,940	266,160 2/
Diversion Structure	20,390	58,010 3/			20,390	58,010 3/
Pipeline	94,390	15,260 4/			94,390	15,260 4/
Project Admin.	27,690	4,380 5/			27,690	4,380 5/
	329,410	343,810			329,410	343,810 6/

1/ As shown in Watershed Work Plan 1970 prices.
2/ Lands for R/W - $181,500; relocation of two natural gas lines - $84,000; power pole relocation - $600; and clothes line relocation - $60.
3/ Lands for R/W - $26,650; Guadalupe Road tunnel conduit - $30,460; lower AT&T cable - $780; and utility company inspectors - $120.
4/ Lands for R/W - $14,780; utility company inspectors - $250; Baseline Road pavement repair - $230.
5/ Includes $1,610 for State of Arizona dam filing fees.
6/ Includes funds budgeted by Arizona Highway Department for right-of-way acquisition.

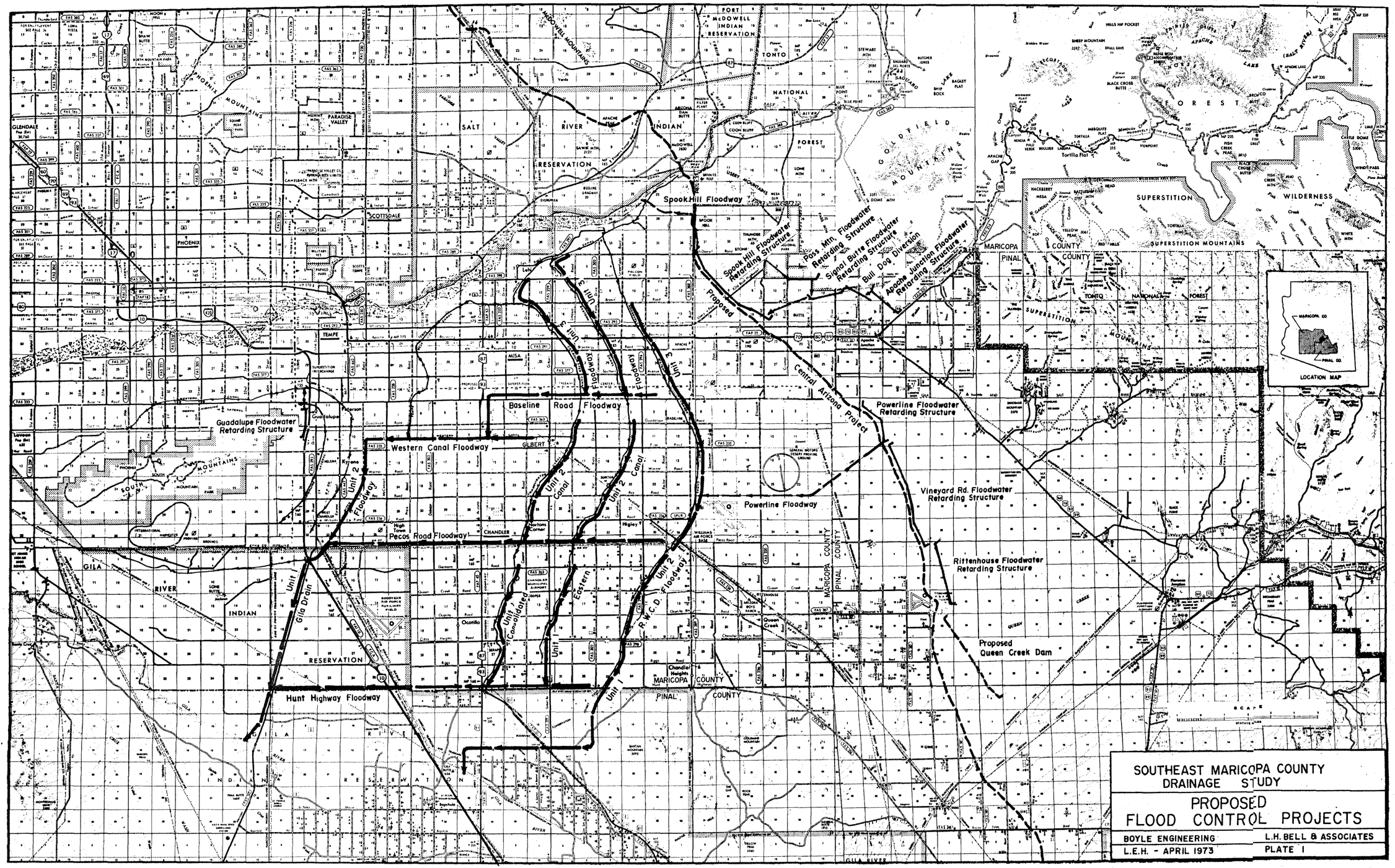
ADDITIONAL PROJECTS REQUIRED IN THE STUDY AREA

The installation of all of the Public Law 566 projects approved for construction, as amended and supplemented, and the measures anticipated for inclusion in the Lower Queen Creek Project will provide protection from the 100-year return period flood flows originating in the area east of the Roosevelt Water Conservation District Canal. The Guadalupe watershed project will provide protection to the community of Guadalupe and Freeway I-10 but will have small effect on the remaining flood problems in the study area.

The area between the Roosevelt Water Conservation District Canal and the western boundary of the drainage area into the Gila Drain includes about 244 square miles. There is no coordinated collector system or outlet channels for the progressively increasing runoff from this area. As urban development expands further, flood problems will become acute without the provision of major outlet channels. The runoff from the areas above the Eastern and Consolidated Canals will exceed the limited capacities of the canals causing breaching of the canals and consequent damages from the released flows. The enlargement of floodways above the canals without an outlet to the Gila River will only transfer the flood problem to the lower areas where the larger accumulated flows are released.

Plate 1 illustrates a project concept of collector systems and major channels to control the flood flows generated in this area. It includes the development of an outlet channel to the Gila River into which the accumulated flows in floodways and other collector channels can be discharged.

This concept essentially divides the area into three units: the area north of Western Canal; the area between Western Canal and Pecos Road; and the area south of Pecos Road.



SOUTHEAST MARICOPA COUNTY
DRAINAGE STUDY

PROPOSED
FLOOD CONTROL PROJECTS

BOYLE ENGINEERING | L.H. BELL & ASSOCIATES

L.E.H. - APRIL 1973 | PLATE I

PRELIMINARY ONLY

The runoff from the area north of Western Canal would be collected in a major floodway along the alignment of Western Canal from Gila Drain easterly to Center Street, thence northerly to Baseline Road, then continuing easterly along Baseline Road to a junction with Eastern Canal. Floodways above Eastern and Consolidated Canals would be provided which would discharge into this floodway.

The development of the flood control plans for this area and for the other areas is contingent upon the completion of adequate capacity in the Gila Drain from the junction with Western Canal to the Gila River.

The major portion of the runoff from the area between Western Canal and Pecos Road would be collected in a floodway extending from the Gila Drain along Pecos Road to Eastern Canal. Floodways above Eastern and Consolidated Canals would discharge into this floodway along with collector laterals in the area west of Consolidated Canal which drains toward Pecos Road. Additional drains in the vicinities of Warner, Ray and Williams Field Roads would discharge directly into Gila Drain.

In the area south of Pecos Road collector systems would be developed to discharge into Gila Drain with a major outlet along Hunt Highway.

Federal assistance to provide major outlet channels for the area west of Roosevelt Water Conservation District Canal may be obtained through the Corps of Engineers or the Soil Conservation Service.

There may be advantages to dividing the area into two parts: one that is anticipated

to be primarily urban within the relatively near future and the other that is anticipated to remain in agriculture for the foreseeable future. The measures required for protection of the urban area, including a portion of the outlet to the Gila River through the Gila Drain, may appropriately be included in a Corps of Engineers flood control project. The measures required for protection of the area anticipated to remain primarily in agricultural use, including a portion of the Gila Drain, may be included in a Public Law 566 project with the advantage that Public Law 566 projects are more oriented to the needs of agriculture.

One of the objectives of this present study is to provide preliminary information which will assist in obtaining assistance in the development of these projects.

HYDROLOGIC ANALYSIS

The watersheds in the study area vary from steep mountains with slopes of 50 percent or greater in the eastern portion to the lands in the farmed areas with very gentle slopes. Soils in the area range from very shallow with sparse desert vegetation to the deep soils in the agricultural areas. In the steep upper watersheds the runoff accumulates in closely spaced channels which run generally in a southwesterly direction. The high velocities in these channels transport large amounts of sediment. As the slopes become less steep sediment is deposited, the channels become less defined and the flood flows tend to spread over large areas.

There are not sufficient runoff data applicable to this area to serve as a basis for estimating peak flood flows for design purposes. Peak flood flows were estimated using the Soil Conservation Service computer program, TR-20, Hydrology for Project Formulation.

Estimated precipitation intensities for 24-hour durations were used in estimating runoff for the various return periods. These were obtained from precipitation maps prepared by the U. S. Weather Bureau for the Soil Conservation Service in 1967 and revised by the Arizona Highway Department in 1970.

Infiltration rates, indicated by curve numbers, were estimated using the hydrologic grouping of soils prepared by the Soil Conservation Service and the present or anticipated land use in the various areas. Land use assumed in the hydrologic analyses was as follows:

1. Area between the Roosevelt Water Conservation District Canal and the Central Arizona Project Canal alignment - saturated urban development between the Salt River and Guadalupe Road with the remainder of the area in its present use.
2. Area north of Western Canal floodway alignment - 100 percent saturated urban development.
3. Area between Western Canal and Pecos Road floodway alignment.
   a. Gila Drain to Consolidated Canal - 50 percent saturated urban development.
   b. Area east of Consolidated Canal to Roosevelt Water Conservation District Canal - agricultural use.
4. Area south of Pecos Road to Maricopa County Line - 15 square miles urban development in close proximity to Highway I-10 with the remainder agricultural use.
5. Area west of Gila Drain and Highway I-10 and north of Pecos Road - 5 square miles urban development with the remainder in its present use.

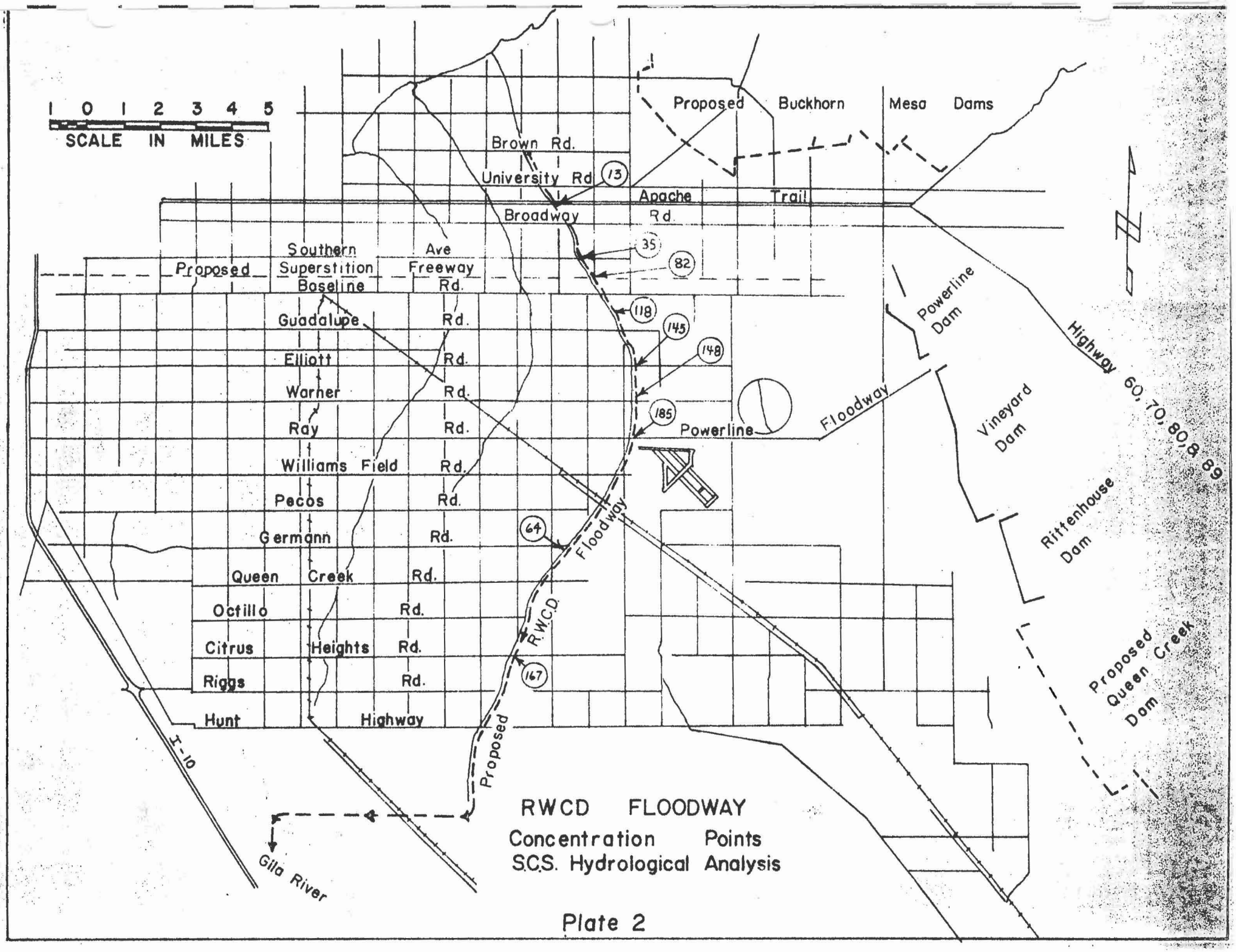
The Soil Conservation Service developed a mathematical hydrologic model for the area east of the Roosevelt Water Conservation District Canal in accordance with their computer program, TR-20, Hydrology for Project Formulation.

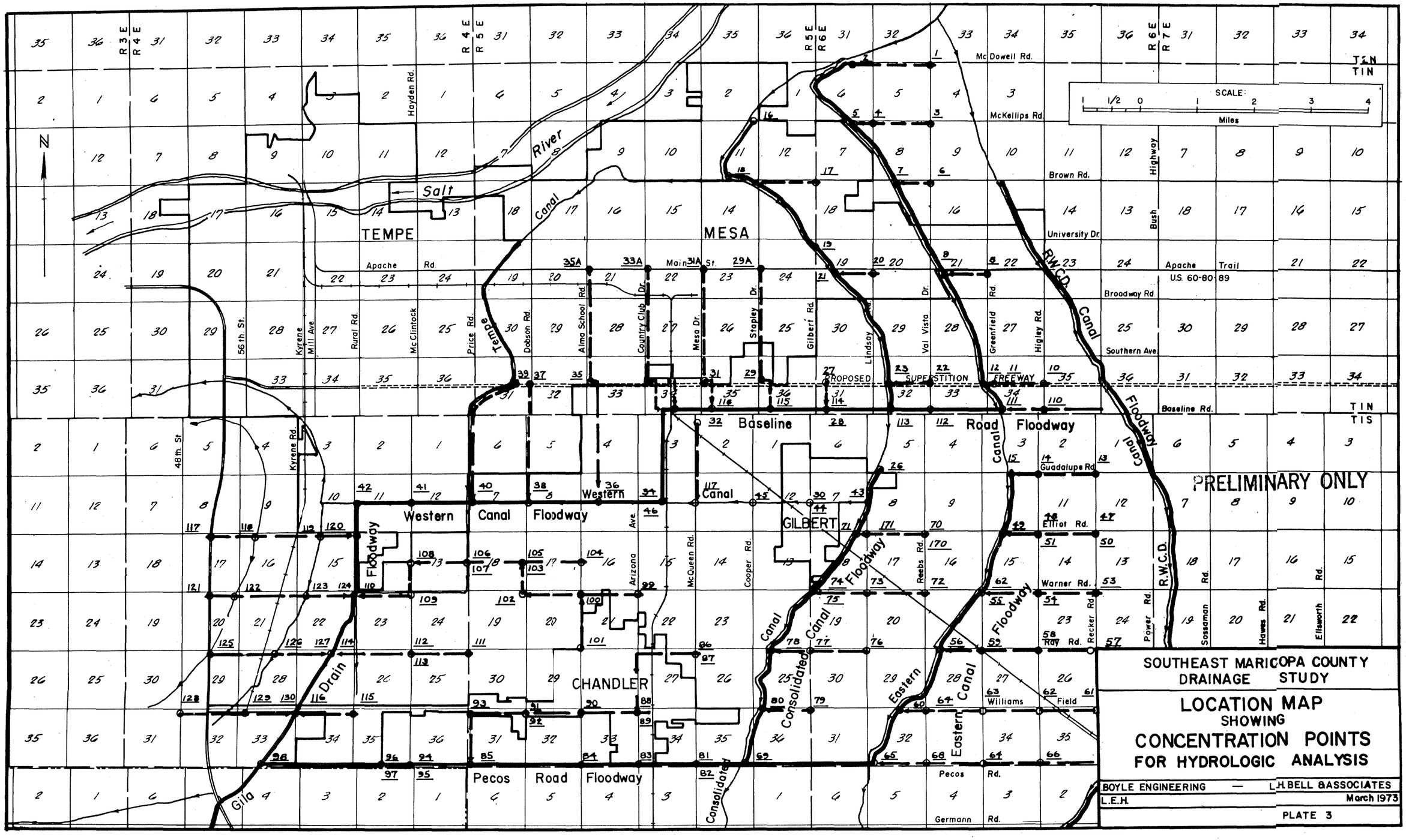
This model provides for rapid analyses by computer to obtain estimates of peak flows at specified concentration points for various conditions of land use and floodwater retarding structures installed in the watershed.

This model was used by the Soil Conservation Service to estimate peak flood flows in the Roosevelt Water Conservation District floodway for various return periods under conditions with and without the Buckhorn-Mesa Project and the Lower Queen Creek Project structural measures installed under present and future conditions; and with these structural measures installed under future conditions. Table 6 summarizes the estimated peak flood flows for concentration points as shown on Plate 2.

A similar hydrologic model was developed for the 244 square mile drainage area west of the Roosevelt Water Conservation District Canal for a project concept of floodways to discharge into the Gila Drain. Table 7 summarizes the estimated peak flood flows estimated for the 100-year return period flood for concentration points shown on Plate 3 and 4.

For the area north of the Superstition Freeway alignment and west of Consolidated Canal, computer runs were made for the estimated 2-, 5-, 10-, 25-, 50- and 100-year return period floods. Table 8 summarizes the estimated peak flood flows and the volumes of runoff for these return periods at considered culvert crossings of the Superstition Freeway.


1 0 1 2 3 4 5
SCALE IN MILES
Proposed Buckhorn Mesa Dams
Brown Rd.
University Rd
13
Apache Trail
Broadway Rd
35
82
Southern Ave
Superstition Freeway
Proposed
Baseline Rd.
Guadalupe Rd.
Elliott Rd.
Warner Rd.
Ray Rd.
Williams Field Rd.
Pecos Rd.
Germann Rd.
Queen Creek Rd.
Octillo Rd.
Citrus Heights Rd.
Riggs Rd.
Hunt Highway
118
145
148
185
64
167
Powerline Dam
Highway 60, 70, 80, & 89
Floodway
Powerline
Vineyard Dam
Rittenhouse Dam
Floodway
R.W.C.D.
Proposed Queen Creek Dam
I-10
Proposed
Gila River
RWCD FLOODWAY
Concentration Points
S.C.S. Hydrological Analysis
Plate 2



SOUTHEAST MARICOPA COUNTY DRAINAGE STUDY

LOCATION MAP SHOWING CONCENTRATION POINTS FOR HYDROLOGIC ANALYSIS

BOYLE ENGINEERING — L.H. BELL & ASSOCIATES

L.E.H.

March 1973

PLATE 3

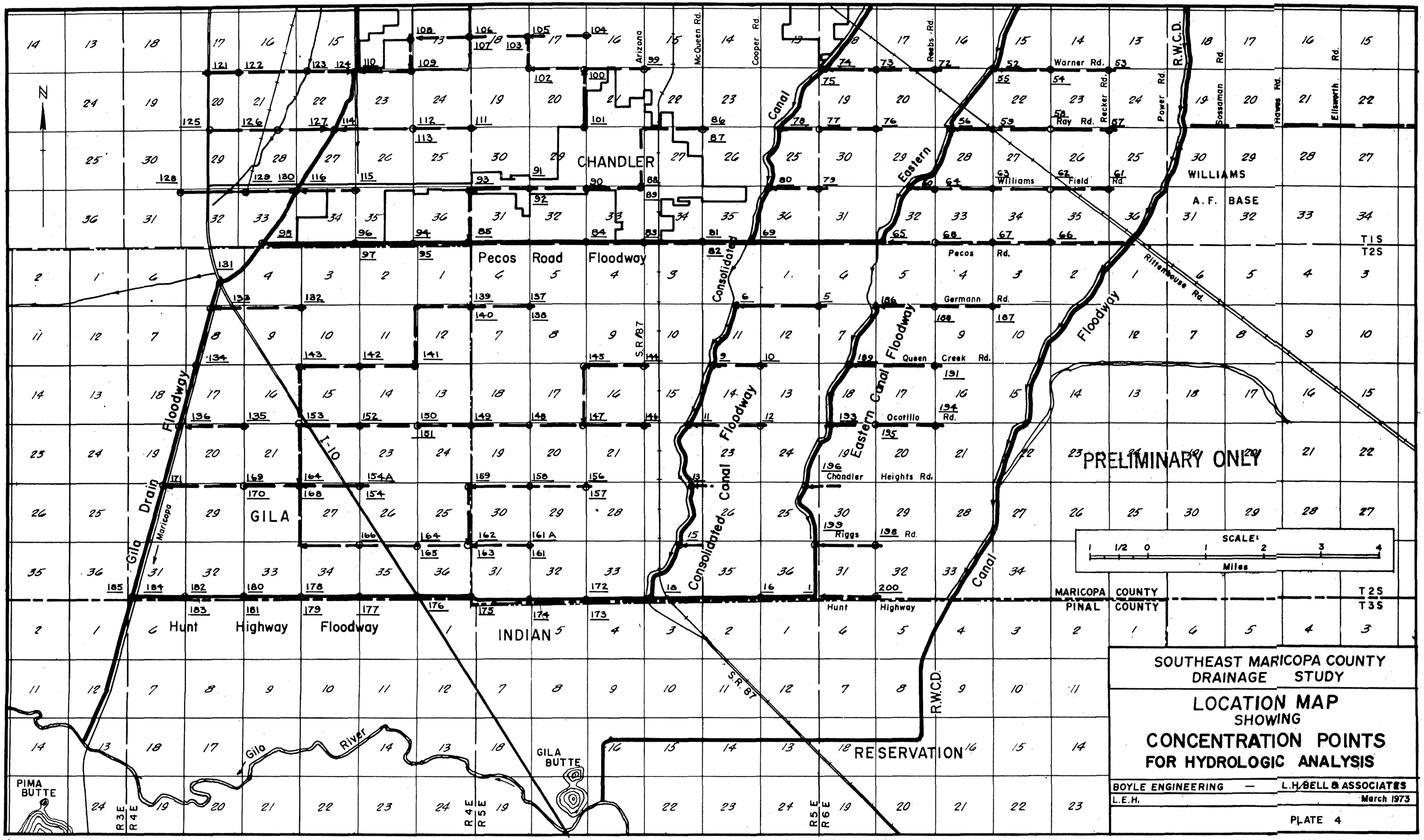

SOUTHEAST MARICOPA COUNTY
DRAINAGE STUDY
LOCATION MAP
SHOWING
CONCENTRATION POINTS
FOR HYDROLOGIC ANALYSIS
BOYLE ENGINEERING — L.H. BELL & ASSOCIATES
L.E.H.
March 1973
PLATE 4
PRELIMINARY ONLY
SCALE:
Miles
N
CHANDLER
WILLIAMS
A. F. BASE
GILA
INDIAN
RESERVATION
GILA BUTTE
PIMA BUTTE
Gila River
Pecos Road Floodway
Hunt Highway Floodway
Gila Drain Floodway
Consolidated Canal
Consolidated Canal Floodway
Eastern Canal
Eastern Canal Floodway
R.W.C.D. Floodway
R.W.C.D. Canal
I-10
S.R. 87
Warner Rd.
Ray Rd.
Williams Field Rd.
Pecos Rd.
Germann Rd.
Queen Creek Rd.
Ocotillo Rd.
Chandler Heights Rd.
Riggs Rd.
Hunt Highway
Arizona
McQueen Rd.
Cooper Rd.
Reebs Rd.
Recker Rd.
Power Rd.
Sossaman Rd.
Hawes Rd.
Ellsworth Rd.
Rittenhouse Rd.
Maricopa
MARICOPA COUNTY
PINAL COUNTY
T1S
T2S
T3S
R3E R4E
R4E R5E
R5E R6E

TABLE 6

ESTIMATED PEAK FLOOD FLOWS[1/]
ROOSEVELT WATER CONSERVATION DISTRICT FLOODWAY

Cross Section No.	Without Buckhorn-Mesa and Lower Queen Creek Project Structural Measures						With Buckhorn-Mesa and Lower Queen Creek Project Structural Measures		
	Present Conditions Return Period - Years			Future Conditions Return Period - Years			Future Conditions Return Period - Years		
	100 cfs	25 cfs	10 cfs	100 cfs	25 cfs	10 cfs	100 cfs	25 cfs	10 cfs
13	2,925	2,170	1,352	4,711	3,628	2,428	3,645	2,797	1,847
35	5,327	3,749	2,311	7,600	5,542	3,612	5,225	3,732	2,318
82	8,438	5,676	3,548	16,834	11,713	7,821	11,691	7,700	4,990
118	9,847	6,508	4,121	19,690	13,522	9,020	13,675	9,174	5,864
145	12,788	8,446	5,423	25,667	17,178	11,391	17,424	11,507	7,243
148	12,675	8,325	5,325	24,980	16,805	10,978	16,881	11,022	7,032
185	15,372	9,911	6,243	28,798	18,966	12,258	20,854	13,483	8,389
64	20,972	13,355	8,237	32,398	21,254	13,785	24,609	15,823	10,068
167	34,863	23,315	16,331	39,848	26,773	18,096	32,295	21,406	14,013

1/ Estimated by U.S.D.A. Soil Conservation Service

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain. Area. Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Western Canal - Baseline Road Floodway		
1	0.24	Eastern Canal Floodway - Rambo Rd.- Lateral	210	210
2	0.46	Eastern Canal Floodway - Rambo Rd.- Lateral	280	
2	0.70	Eastern Canal Floodway - Rambo Rd.- Lateral		440
3	0.61	Eastern Canal Floodway - So. of Rambo Rd.-Lateral	380	380
4	1.00	Eastern Canal Floodway - So. of Rambo Rd.-Lateral	590	900
5	0.84	Eastern Canal Floodway - So. of Rambo Rd.-Lateral	530	
5	2.45	Eastern Canal Floodway - So. of Rambo Rd.-Lateral		1300
5	3.15	Eastern Canal Floodway		1570
6	0.97	Eastern Canal Floodway - Brown Rd. - Lateral	670	670
7	1.07	Eastern Canal Floodway - Brown Rd. - Lateral	600	
7	2.04	Eastern Canal Floodway - Brown Rd. - Lateral		1200
7	5.19	Eastern Canal Floodway		2380
8	0.78	Eastern Canal Floodway - Apache Trail - Lateral	540	540
9	2.12	Eastern Canal Floodway - Apache Trail - Lateral	1420	
9	2.90	Eastern Canal Floodway - Apache Trail - Lateral		1910
9	8.09	Eastern Canal Floodway		3210
10	1.07	Eastern Canal Floodway - Lateral	650	650
11	1.97	Eastern Canal Floodway - Lateral	970	1570
12	0.71	Eastern Canal Floodway - Lateral	360	
12	13.75	Eastern Canal Floodway - Lateral		1910
12	11.84	Eastern Canal Floodway		3900
110	0.57	Eastern Canal Floodway - Baseline Rd. - Lateral	430	430
111	0.46	Eastern Canal Floodway - Baseline Rd. - Lateral	390	
111	1.03	Eastern Canal Floodway - Baseline Rd.- Lateral		670
111	12.87	Eastern Canal Floodway		4000

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Western Canal - Baseline Road Floodway (Continued)		
112	0.30	Baseline Road Floodway - Lateral	270	
112	13.17	Baseline Road Floodway		4010
113	0.38	Baseline Road Floodway - Lateral	370	
113	13.55	Baseline Road Floodway		4030
16	0.78	Consolidated Canal Floodway - Lateral	560	560
17	0.91	Consolidated Canal Floodway - Brown Rd. - Lateral	580	
18	1.49	Consolidated Canal Floodway - Brown Rd. - Lateral	730	
18	2.40	Consolidated Canal Floodway - Brown Rd. - Lateral		1050
18	3.18	Consolidated Canal Floodway		1500
19	0.67	Consolidated Canal Floodway - Lateral	440	
19	3.85	Consolidated Canal Floodway		1410
20	1.02	Consolidated Canal Floodway - Apache Trail - Lateral	860	860
21	1.45	Consolidated Canal Floodway - Apache Trail - Lateral	960	
21	2.47	Consolidated Canal Floodway - Apache Trail - Lateral		1720
21	6.32	Consolidated Canal Floodway		2250
22	1.20	Consolidated Canal Floodway - Superstition Freeway - Lat.	800	800
23	2.23	Consolidated Canal Floodway - Superstition Freeway - Lat.	1270	
23	3.43	Consolidated Canal Floodway - Superstition Freeway - Lat.		2000
23	9.75	Consolidated Canal Floodway		3010
113	23.30	Baseline Road Floodway		6920
27	1.77	Baseline Road Floodway- Gilbert Rd. - No. Lateral	1100	
114	0.61	Baseline Road Floodway - Gilbert Rd. - No. Lateral	400	
114	25.68	Baseline Road Floodway		7150

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Western Canal - Baseline Road Floodway (Continued)		
28	1.73	Baseline Road Floodway - So. Lateral	860	
28	27.41	Baseline Road Floodway		7510
29A	0.87	Baseline Road Floodway - Cooper Road - Lateral	510	
29	1.99	Baseline Road Floodway - Cooper Road - Lateral	920	
115	2.86	Baseline Road Floodway - Cooper Road - Lateral		1170
115	0.50	Baseline Road Floodway - Cooper Road - Lateral	330	
115	30.77	Baseline Road Floodway		7940
31A	1.48	Baseline Road Floodway - McQueen Road - No. Lateral	600	
31	2.02	Baseline Road Floodway - McQueen Road - No. Lateral	820	
116	3.50	Baseline Road Floodway - McQueen Road - No. Lateral		1070
116	0.36	Baseline Road Floodway - McQueen Road - No. Lateral	190	
32	1.64	Baseline Road Floodway - McQueen Road - So. Lateral	610	
116	36.27	Baseline Road Floodway		8610
117	0.64	Baseline Road Floodway - McQueen Road - Lateral	180	
117	36.91	Western Canal Floodway		8590
43	0.84	Western Canal Floodway - Gilbert Trib.	520	520
30	1.48	Western Canal Floodway - Gilbert Trib.	660	
44	2.09	Western Canal Floodway - Gilbert Trib.	1070	2210
45	1.51	Western Canal Floodway - Gilbert Trib.	780	
45	5.92	Western Canal Floodway - Gilbert Trib.		2890
117	42.83	Western Canal Floodway - Jct. w/ Gilbert Trib.		9290
33A	1.48	Western Canal Floodway - Arizona Ave. - No. Lateral	600	
33	1.98	Western Canal Floodway - Arizona Ave. - No. Lateral	800	1060
34	1.35	Western Canal Floodway - Arizona Ave. - No. Lateral	370	
34	4.81	Western Canal Floodway - Arizona Ave. - No. Lateral		1380
46	1.51	Western Canal Floodway - Arizona Ave. - So. Lateral	780	
34	49.15	Western Canal Floodway - Arizona Ave.		10,420
35A	0.82	Western Canal Floodway - Alma School Road - Lateral	420	
35	1.96	Western Canal Floodway - Alma School Road - Lateral	830	1020

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
[illegible]	[illegible]	Western Canal - Baseline Road Floodway (Continued)		
36	1.98	Western Canal Floodway - Alma School Road	640	
36	4.76	Western Canal Floodway - Alma School Road		1550
36	53.91	Western Canal Floodway - Alma School Road		11, 250
37	2.02	Western Canal Floodway - Dobson Road - Lateral	860	
38	1.98	Western Canal Floodway - Dobson Road - Lateral	710	
38	4.00	Western Canal Floodway - Dobson Road - Lateral		1410
38	57.91	Western Canal Floodway - Dobson Road		11,840
39	1.05	Western Canal Floodway - Tempe Canal - Lateral	360	
40	1.90	Western Canal Floodway - Tempe Canal - Lateral	730	
40	2.95	Western Canal Floodway - Tempe Canal - Lateral		900
[illegible]0	60.86	Western Canal Floodway - Tempe Canal		12,300
41	0.87	Western Canal Floodway - McClintock Road - Lateral	320	
41	61.73	Western Canal Floodway - McClintock Road		12,370
42	0.60	Western Canal Floodway - Rural Road - Lateral	170	
42	62.33	Western Canal Floodway - Rural Road - Jct. Gila Drain		12,430
117	1.61	Elliot Road Lateral to Gila Drain (West)	1000	1000
118	0.55	Elliot Road Lateral to Gila Drain (West)	430	1260
119	0.79	Elliot Road Lateral to Gila Drain (West)	30	1210
120	0.52	Elliot Road Lateral to Gila Drain (West)	30	
120	3.47	Elliot Road Lateral to Gila Drain (West)		1200
120	65.80	Gila Drain, Jct. w/ Elliot Road, Lateral (West)		12,550
121	2.77	Warner Road Lateral to Gila Drain (West)	880	880
122	0.65	Warner Road Lateral to Gila Drain (West)	450	1150
123	1.25	Warner Road Lateral to Gila Drain (West)	90	1200
124	0.74	Warner Road Lateral to Gila Drain (West)	30	
[illegible]4	5.41	Warner Road Lateral to Gila Drain (West)		1200

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Warner Road Lateral (East)		
99	1.00	Warner Road	570	570
100	1.00	Alma School Road Jct.	620	
101	1.02	Alma School Road	540	
100	3.02	Warner Road		1620
102	1.00	Warner Road at Dobson Road	550	
102	4.02	Warner Road at Dobson Road		2080
103	0.50	Dobson Road	290	
103	4.52	Dobson Road		2270
104	1.51	East Lateral No. of Warner Road	720	720
105	1.01	East Lateral No. of Warner Road	520	1180
105	7.04	Jct. on Dobson Road		3440
106	1.00	North Lateral at Price Road	140	
107	0.48	South Lateral at Price Road	70	
107	8.52	At Price Road		3560
08	1.02	At McClintock Drive	60	3570
109	0.50	Warner Road and McClintock Drive	60	3590
110	1.53	Junction w/Gila Drain	40	
110	11.57	Junction w/Gila Drain		3580
110	82.78	Gila Drain - Jct. w/Warner Road Laterals		13,960
125	2.28	Ray Road Lateral (West)	270	270
126	1.50	Ray Road Lateral (West)	100	350
127	0.94	Ray Road Lateral (West)	60	
127	4.72	Ray Road Lateral (West)		390
111	0.99	Ray Road Lateral (East)	100	100
112	1.02	Ray Road Lateral (East)	100	
113	1.02	Ray Road Lateral (East)	50	240
114	1.13	Ray Road Lateral (East)	30	
114	4.16	Ray Road Lateral (East)		270
114	91.66	Gila Drain - Jct. w/Ray Road Laterals		14,240
128	0.74	Williams Field Road Lateral (West)	30	30
129	0.90	Williams Field Road Lateral (West)	50	80
30	0.98	Williams Field Road Lateral (West)	140	
130	2.62	Williams Field Road Lateral (West)		210

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Warner Road Lateral (East) Continued		
115	0.99	Williams Field Road Lateral (East)	30	30
116	0.67	Williams Field Road Lateral (East)	20	
116	1.66	Williams Field Road Lateral (East)		50
116	95.94	Gila Drain - Jct. Williams Field Road Laterals		14,290
		Pecos Road Floodway		
13	0.71	Eastern Canal Floodway - Guadalupe Road - Lateral	30	30
14	0.98	Eastern Canal Floodway - Guadalupe Road - Lateral	30	60
15	0.59	Eastern Canal Floodway - Guadalupe Road - Lateral	50	
15	2.28	Eastern Canal Floodway - Guadalupe Road - Lateral		100
47	1.14	Eastern Canal Floodway - Elliot Road - Lateral	150	150
50	1.28	Eastern Canal Floodway - Elliot Road - Lateral	150	270
48	1.01	Eastern Canal Floodway - Elliot Road - Lateral	150	400
51	0.98	Eastern Canal Floodway - Elliot Road - Lateral	120	520
49	0.55	Eastern Canal Floodway - Elliot Road - Lateral	80	
49	4.96	Eastern Canal Floodway - Elliot Road		580
49	7.24	Eastern Canal Floodway - Elliot Road		670
53	1.21	Eastern Canal Floodway - Warner Road - Lateral	140	140
54	0.97	Eastern Canal Floodway - Warner Road - Lateral	150	250
52	0.85	Eastern Canal Floodway - Warner Road - Lateral	100	350
55	0.97	Eastern Canal Floodway - Warner Road - Lateral	150	
55	4.00	Eastern Canal Floodway - Warner Road - Lateral		470
55	11.24	Eastern Canal Floodway - Warner Road		1080
57	1.0			
57	1.06	Eastern Canal Floodway - Ray Road - Lateral	130	130
58	0.99	Eastern Canal Floodway - Ray Road - Lateral	120	250
59	0.99	Eastern Canal Floodway - Ray Road - Lateral	120	350
56	0.46	Eastern Canal Floodway - Ray Road - Lateral	50	
56	3.50	Eastern Canal Floodway - Ray Road - Lateral		400
56	14.74	Eastern Canal Floodway - Ray Road		1430

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Pecos Road Floodway (Continued)		
61	0.58	Eastern Canal Floodway - Wms Field Road - Lateral	50	50
62	0.99	Eastern Canal Floodway - Wms. Field Road - Lateral	130	180
63	0.99	Eastern Canal Floodway - Wms. Field Road - Lateral	130	300
64	0.99	Eastern Canal Floodway - Wms. Field Road - Lateral	110	390
60	1.04	Eastern Canal Floodway - Wms. Field Road - Lateral	110	
60	4.59	Eastern Canal Floodway - Wms. Field Road - Lateral		500
60	19.33	Eastern Canal Floodway - Wms. Field Road		1750
66	0.83	Eastern Canal Floodway - Pecos Road No. Lateral	40	40
67	1.00	Eastern Canal Floodway - Pecos Road No. Lateral	40	70
68	1.00	Eastern Canal Floodway - Pecos Road No. Lateral	30	100
65	0.78	Eastern Canal Floodway - Pecos Road No. Lateral	80	
65	3.63	Eastern Canal Floodway - Pecos Road No. Lateral		180
65	22.96	Eastern Canal Floodway - Pecos Road		1830
69	1.10	Eastern Canal Floodway - Pecos Road, So. Lateral	140	
69	24.06	Eastern Canal Floodway - Pecos Road		1860
26	2.09	Consolidated Canal Floodway - Guadalupe Road - Lateral	230	
26	2.09	Consolidated Canal Floodway - Guadalupe Road - Lateral		230
70	1.33	Consolidated Canal Floodway - Elliot Road - Lateral	150	150
170	1.11	Consolidated Canal Floodway - Elliot Road - Lateral	170	290
171	0.99	Consolidated Canal Floodway - Elliot Road - Lateral	120	410
71	1.03	Consolidated Canal Floodway - Elliot Road - Lateral	130	
71	4.46	Consolidated Canal Floodway - Elliot Road - Lateral		530
71	6.55	Consolidated Canal Floodway - Elliot Road		720
72	0.52	Consolidated Canal Floodway - Warner Road - Lateral	100	100
73	1.00	Consolidated Canal Floodway - Warner Road - Lateral	130	220
74	0.54	Consolidated Canal Floodway - Warner Road - Lateral	210	420
75	0.99	Consolidated Canal Floodway - Warner Road - Lateral	150	
75	3.05	Consolidated Canal Floodway - Warner Road - Lateral		550
75	9.60	Consolidated Canal Floodway - Warner Road		1100

TABLE 7
ESTIMATED PEAK FLOOD FLOWS
100 - YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain Area Sq. Mi.	Location	Lateral cfs	Main Channel cfs
		Pecos Road Floodway (Continued)		
76	0.95	Consolidated Canal Floodway - Ray Road - Lateral	120	120
77	0.97	Consolidated Canal Floodway - Ray Road - Lateral	110	230
78	0.40	Consolidated Canal Floodway - Ray Road - Lateral	40	
78	2.32	Consolidated Canal Floodway - Ray Road - Lateral		270
78	11.92	Consolidated Canal Floodway - Ray Road		1270
79	1.19	Consolidated Canal Floodway - Wms. Field Road - Lateral	190	190
80	0.83	Consolidated Canal Floodway - Wms. Field Road - Lateral	100	
80	2.02	Consolidated Canal Floodway - Wms. Field Road - Lateral		280
80	13.94	Consolidated Canal Floodway - Wms. Field Road		1360
69	38.00	Pecos Road Floodway		3190
81	0.90	Pecos Road Floodway- McQueen Road	100	
82	0.57	Pecos Road Floodway - McQueen Road	20	3230
83	1.02	Pecos Road Floodway - Arizona Avenue	30	3230
84	1.03	Pecos Road Floodway- Alma School Road	70	3260
85	1.04	Pecos Road Floodway - Price Road	70	
85	42.56	Pecos Road Floodway - Price Road		3260
86	0.99	Tributary to Pecos Road Floodway - Ray Road	510	
87	1.15	Tributary to Pecos Road Floodway - Ray Road	130	620
88	1.00	Tributary to Pecos Road Floodway - Arizona Avenue	540	
89	0.99	Tributary to Pecos Road Floodway - Arizona Avenue	540	1510
90	1.00	Tributary to Pecos Road Floodway - Alma School Road	540	1940
91	1.01	Tributary to Pecos Road Floodway - Dobson Road	570	
92	1.00	Tributary to Pecos Road Floodway - Dobson Road	620	2710
93	1.00	Tributary to Pecos Road Floodway - Price Road	130	
93	8.14	Tributary to Pecos Road Floodway - Price Road		2810
85	40.70	Pecos Road Floodway - Jct. w/Price Road Trib.		3930
94	1.00	Pecos Road Floodway - McClintock Drive	30	
95	0.90	Pecos Road Floodway - McClintock Drive	20	3950
96	1.02	Pecos Road Floodway - Canal Drive	30	
97	0.94	Pecos Road Floodway - Canal Drive	30	3970

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain. Area Sq.Mi.	Location	Lateral cfs	Main Channel cfs
		Pecos Road Floodway (Continued)		
98	1.30	Pecos Road Floodway, Jct. W/Gila Drain	30	
98	55.86	Pecos Road Floodway, Jct. W/Gila Drain		3,960
98	151.80	Gila Drain, Jct. w/Pecos Rd. Floodway		18,040
131	1.72	Tributary to Gila Drain (West)	200	18,050
133	1.99	German Road Lateral	50	18,080
134	1.59	Queen Creek Road Lateral	590	18,130
136	1.99	Ocotillo Road Lateral	730	
136	159.09	Gila Drain, Jct. Ocotillo Rd. Lateral		18,200
		Chandler Heights Rd. Drain and Laterals		
138	2.07	Germann Rd. Lateral	70	70
139	1.05	Germann Rd. Lateral	30	
140	0.99	Germann Rd. Lateral	40	120
141	0.93	Jct. w/Queen Creek Rd. Lateral	20	140
142	0.99	Queen Creek Rd. Lateral	30	160
143	0.99	Queen Creek Rd. Lateral	30	
143	7.02	Queen Creek Rd. Lateral		180
144	1.27	Queen Creek Rd. Upper Lateral	30	30
145	0.99	Queen Creek Rd. Upper Lateral	20	50
147	1.96	Ocotillo Rd. Lateral	50	100
148	1.03	Ocotillo Rd. Lateral	30	120
149	0.99	Ocotillo Rd. Lateral	30	140
150	0.94	Ocotillo Rd. Lateral	20	
151	0.94	Ocotillo Rd. Lateral	30	180
152	1.00	Ocotillo Rd. Lateral	30	200
153	1.00	Ocotillo Rd. Lateral	440	
153	10.12	Ocotillo Rd. Lateral		450

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain. Area Sq.Mi.	Location	Lateral cfs	Main Channel cfs
		Chandler Heights Rd Drain and Laterals (Continued)		
153	17.14	Jct. Queen Creek Rd. and Ocotillo Rd Lateral		470
154A	0.99	Lower Chandler Heights Rd. Lateral	400	
154	0.99	Lower Chandler Heights Rd. Lateral	370	760
167	1.00	Lower Chandler Heights Rd. Lateral	440	
168	1.00	Lower Chandler Heights Rd. Lateral	440	
168	3.98	Lower Chandler Heights Rd. Lateral		1,520
168	21.12	Lower Chandler Heights Rd. Lateral		1,970
157	3.24	Chandler Heights Road	80	80
158	1.00	Chandler Heights Road	30	105
159	1.01	Chandler Heights Road	30	
159	5.25	Chandler Heights Road		130
161	2.00	Riggs Road	50	50
162	1.01	Riggs Road	430	
163	1.00	Riggs Road	440	
163	4.01	Riggs Road		880
163	9.26	Jct. Riggs Road and Chandler Heights Road Tribs.		890
164	0.95	Riggs Road	410	
165	0.95	Riggs Road	400	1,640
166	0.99	Riggs Road	400	
166	12.15	Riggs Road		1,980
168	33.27	Jct. All Laterals		3,440
169	1.00	Chandler Heights Rd. Drain	370	
170	1.00	Chandler Heights Rd. Drain	30	3,700
171	1.14	Chandler Heights Rd. Drain	30	
171	36.41	Chandler Heights Rd. Drain		3,690

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain. Area Sq.Mi.	Location	Lateral cfs	Main Channel cfs
171	195.50	Gila Drain Jct. w/Chandler Hts. Rd. Drain		19,200
		Hunt Highway Drain - Eastern Canal Floodway		
187	1.02	Germann Rd. Lateral	40	40
188	1.02	Germann Rd. Lateral	30	70
186	1.08	Germann Rd. Lateral	30	
186	3.12	Germann Rd. Lateral		100
191	1.53	Queen Creek Rd. Lateral	40	40
189	1.30	Queen Creek Rd. Lateral	40	
189	2.83	Queen Creek Rd. Lateral		70
189	5.95	Eastern Canal Floodway		170
194	1.20	Ocatillo Rd. Lateral	30	30
195	1.00	Ocatillo Rd. Lateral	30	60
193	1.78	Ocatillo Rd. Lateral	50	
193	3.98	Ocatillo Rd. Lateral		110
193	9.93	Eastern Canal Floodway		270
196	1.08	Chandler Heights Road Lateral	30	300
198	1.51	Riggs Road Lateral	40	
199	1.21	Riggs Road Lateral	40	
199	2.72	Riggs Road Lateral		80
199	13.73	Eastern Canal Floodway		350

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain. Area Sq.Mi.	Location	Lateral cfs	Main Channel cfs
		Hunt Highway Drain - Eastern Canal Floodway (Continued)		
200	1.50	Hunt Hwy. Lateral	40	
1	1.12	Hunt Hwy. Lateral	30	70
1	16.35	Eastern Canal Floodway at Hunt Hwy.		410
16	0.99	Hunt Hwy. Drain	30	430
18	1.78	Hunt Hwy. Drain	40	
18	19.12	Hunt Hwy. Drain		460
		Consolidated Canal Floodway		
5	0.91	Germann Road Lateral	20	
6	1.45	Germann Road Lateral	40	
6	2.36	Germann Road Lateral		60
10	1.20	Queen Creek Road Lateral	30	30
9	2.39	Queen Creek Road Lateral	60	
9	3.59	Queen Creek Road Lateral		90
9	5.95	Consolidated Canal Floodway		150
12	0.89	Ocotillo Road Lateral	20	
11	1.10	Ocotillo Road Lateral	30	
11	1.99	Ocotillo Road Lateral		50
11	7.94	Consolidated Canal Floodway		200
13	1.41	Chandler Heights Road Lateral	40	230
15	2.05	Riggs Road Lateral	60	270

TABLE 7

ESTIMATED PEAK FLOOD FLOWS
100-YEAR RETURN PERIOD
GILA DRAIN AND TRIBUTARIES

Cross Section No.	Drain. Area Sq.Mi.	Location	Lateral cfs	Main Channel cfs
18	30.52	Hunt Hwy. Drain, Jct. Consol. Canal Floodway		720
173	1.36	Hunt Hwy. Drain	30	750
174	1.66	Hunt Hwy. Drain	40	780
175	1.56	Hunt Hwy. Drain	40	800
176	1.56	Hunt Hwy. Drain	40	830
177	1.33	Hunt Hwy. Drain	40	850
178	0.99	Hunt Hwy. Drain	400	
179	1.25	Hunt Hwy. Drain	40	910
180	0.99	Hunt Hwy. Drain	20	
181	1.48	Hunt Hwy. Drain	40	940
182	0.99	Hunt Hwy. Drain	30	
183	1.40	Hunt Hwy. Drain	40	970
184	2.15	Hunt Hwy. Drain	50	
185	1.16	Hunt Hwy. Drain	30	
185	48.40	Hunt Hwy. Drain		1,020
185	243.90	Gila Drain, Jct. w/Hunt Hwy. Drain		20,130

TABLE 8

ESTIMATED PEAK FLOOD FLOW AND VOLUMES OF RUNOFF
AREA NORTH OF SUPERSTITION FWY. ALIGNMENT AND WEST OF CONSOLIDATED CANAL
FOR VARIOUS RETURN PERIODS

Return Period Years		CONCENTRATION POINTS - NUMBER AND DRAINAGE AREA						
	Column Number 1/	1	2	3	4	5	6	7
	D. A. Sq. Mi.	1.77	2.86	3.50	1.73	1.73	2.78	3.07
2	Peak cfs	145	105	75	35	35	65	80
	Volume - Ac. Ft.	35	35	33	16	16	26	29
5	Peak cfs	305	265	210	100	100	190	230
	Volume - Ac. Ft.	67	77	77	38	38	61	68
10	Peak cfs	455	425	350	170	170	325	390
	Volume - Ac. Ft.	96	116	122	60	60	96	106
25	Peak cfs	685	700	600	295	295	560	675
	Volume - Ac. Ft.	142	183	197	98	98	156	173
50	Peak cfs	930	995	875	430	430	825	990
	Volume - Ac. Ft.	192	256	281	139	139	223	246
100	Peak cfs	1,100	1,200	1,070	530	530	1,010	1,220
	Volume - Ac. Ft.	225	307	341	168	168	270	298

1/ Culvert Crossing Concentration Points
1. 1.77 sq. mi - Gilbert Road Crossing
2. 2.86 sq. mi. - Stapley Drive Crossing
3. 3.50 sq. mi. - Mesa Drive Crossing
4. 1.73 sq. mi. - Center Street Crossing
5. 1.73 sq. mi. - Country Club Drive
6. 2.78 sq. mi. - Alma School Road
7. 3.07 sq. mi. - Tempe Canal

The peak flood flows for the 100-year return period floods were estimated using the output from the computer runs. Peak flood flows for the 50-,25-, and 10-year return periods were estimated for specific drainage areas using factors representing the ratios of the more frequently occurring peak flows to the 100-year return period peak flows. These factors were estimated on the basis of the weighted curve numbers (indicating infiltration rates resulting from the combination of land use and hydrologic characteristics of the soils) for each drainage area considered. The factors are the ratios of the runoff which is estimated to occur with the 24-hour duration precipitation intensities for the 50-, 25-, and 10-year return periods to that which is estimated to occur for the 100-year return period intensity.

Table 9 shows the factors estimated for each of the drainage areas considered and the peak flood flows for various return periods estimated by the application of these factors. Drainage areas that are primarily in agricultural use have lower factors for the more frequently occurring floods. This is because of the higher infiltration rates which absorb a greater proportion of the lower precipitation intensities.

As these drainage areas were generally selected on the basis of consistency of land use within them the factor may be applied generally to all estimated 100-year return period peak flood flows in the areas. The factors developed for the total drainage areas with combinations of land uses and soils above major outlet channels are applicable to the outlet channels only. Table 9 indicates the extent to which there factors may be applied.

Standard project floods as developed by the Corps of Engineers are estimated or hypothetical floods that might be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably

TABLE 9

ESTIMATED PEAK FLOOD FLOWS 100-, 50-, 25- AND 10-YEAR RETURN PERIODS
FOR SELECTED DRAINAGE AREAS WITH SIMILAR RUNOFF CHARACTERISTICS

	Sq.Mi.	100-Year cfs	100-Year F	50-Year cfs	50-Year F	25-Year cfs	25-Year F	10-Year cfs	10-Year F	Factors Generally Applicable to
Western Canal - Baseline Rd. Floodway										
Eastern Canal Floodway	13.55	4,030	1.00	3,380	0.84	2,340	0.58	1,730	0.43	All Channels
Consolidated C. Floodway	9.75	3,010	1.00	2,530	0.84	1,750	0.58	1,290	0.43	
Total drainage area	62.32	12,430	1.00	10,440	0.84	7,210	0.58	5,340	0.43	
Pecos Road Floodway										
Area above Jct. Price Rd. Tributary	42.55	3,260	1.00	2,380	0.73	1,300	0.40	680	0.21	All Channels
Price Road Tributary	8.14	2,810	1.00	2,360	0.84	1,660	0.59	1,260	0.45	All Channels
Total drainage area	55.85	3,960	1.00	2,970	0.75	1,700	0.43	1,030	0.26	Main channel below Jct. Price Rd.Trib.
Hunt Hwy Drain - Total Area	48.39	1,020	1.00	450	0.44	210	0.21	50	0.05	All Channels
Chandler Heights Road Floodway										
Riggs Road Trib.	12.15	1,970	1.00	1,440	0.73	790	0.40	410	0.21	All Channels
Germann Rd.-Queen Cr.Rd.-Ocotillo Rd. Trib.	17.14	470	1.00	260	0.55	120	0.26	40	0.09	All Channels
Total drainage area	36.41	3,690	1.00	2,730	0.74	1,550	0.42	920	0.25	Outlet Channel
Gila Drain										
Jct. with Western C. F.W.	62.32	12,430	1.00	10,440	0.84	7,210	0.58	5,340	0.43	Gila Drain at Junction Points Indicated.
Jct. with Wms.Field Rd.Dr.	95.94	14,290	1.00	11,720	0.82	8,000	0.56	5,860	0.41	
Jct.with Pecos Rd. F.W.	151.79	18,040	1.00	14,430	0.80	9,380	0.52	6,490	0.36	
Jct. with Chandler Hts.F.W.	195.49	19,200	1.00	15,170	0.79	9,600	0.50	6,530	0.34	
Jct.with Hunt Hwy.Drain	243.89	20,130	1.00	15,500	0.77	9,300	0.46	6,100	0.30	

characteristic of the geographical region involved. Estimated flood frequencies estimated by the Corps of Engineers for Indian Bend Wash at Thomas Road are shown in Table 10 .

TABLE 10
ESTIMATED FLOOD FREQUENCIES
INDIAN BEND WASH AT THOMAS ROAD
CORPS OF ENGINEERS FLOOD SURVEY REPORT

Number of Times that Flood Would be Equaled or Exceeded in 100 Years	Uncontrolled Peak Discharges Cubic Feet Per Second	Ratios to 100 Years Return Period
0.23 (Standard Project Flood	72,000	1.8000
1.0	40,000	1.0000
5.0	19,000	0.4750
10.0	12,500	0.3125
20.0	7,600	0.1900
50.0	2,900	0.0725
72.0	1,500	0.0375

These ratios to the 100-year return period flood flows are consistent with those obtained for the Gila Drain for the more frequently occurring floods. On this basis it may be estimated that the standard project floods for the Gila Drain and the major outlet channels may be about 80 percent higher than the estimates for the 100- year return period floods.

ESTIMATED COSTS TO INSTALL ADDITIONAL PROJECTS REQUIRED IN THE STUDY AREA

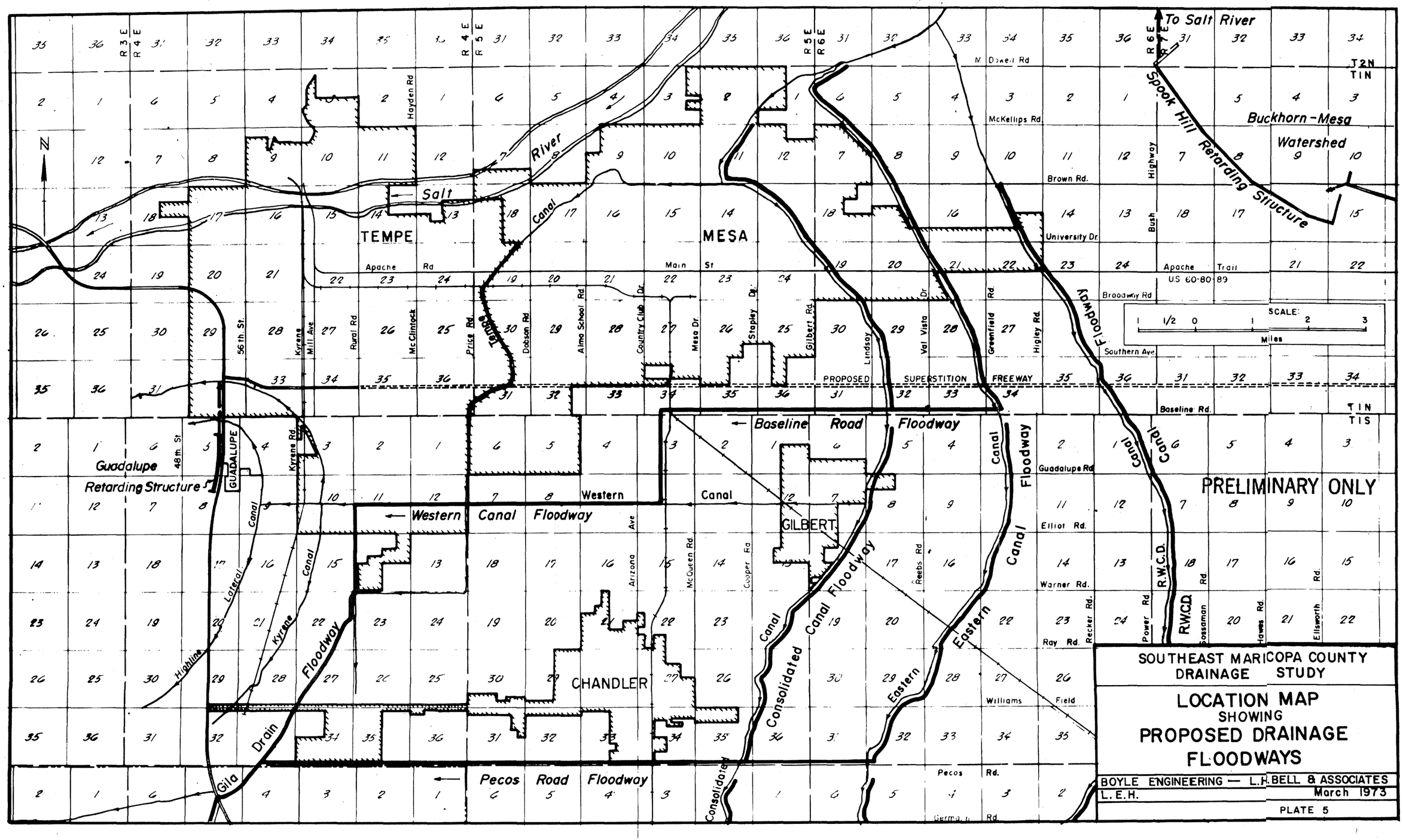
The costs to install the major channels and floodways as shown on Plates 5 and 6 were estimated for unlined earth sections and for concrete lined sections.

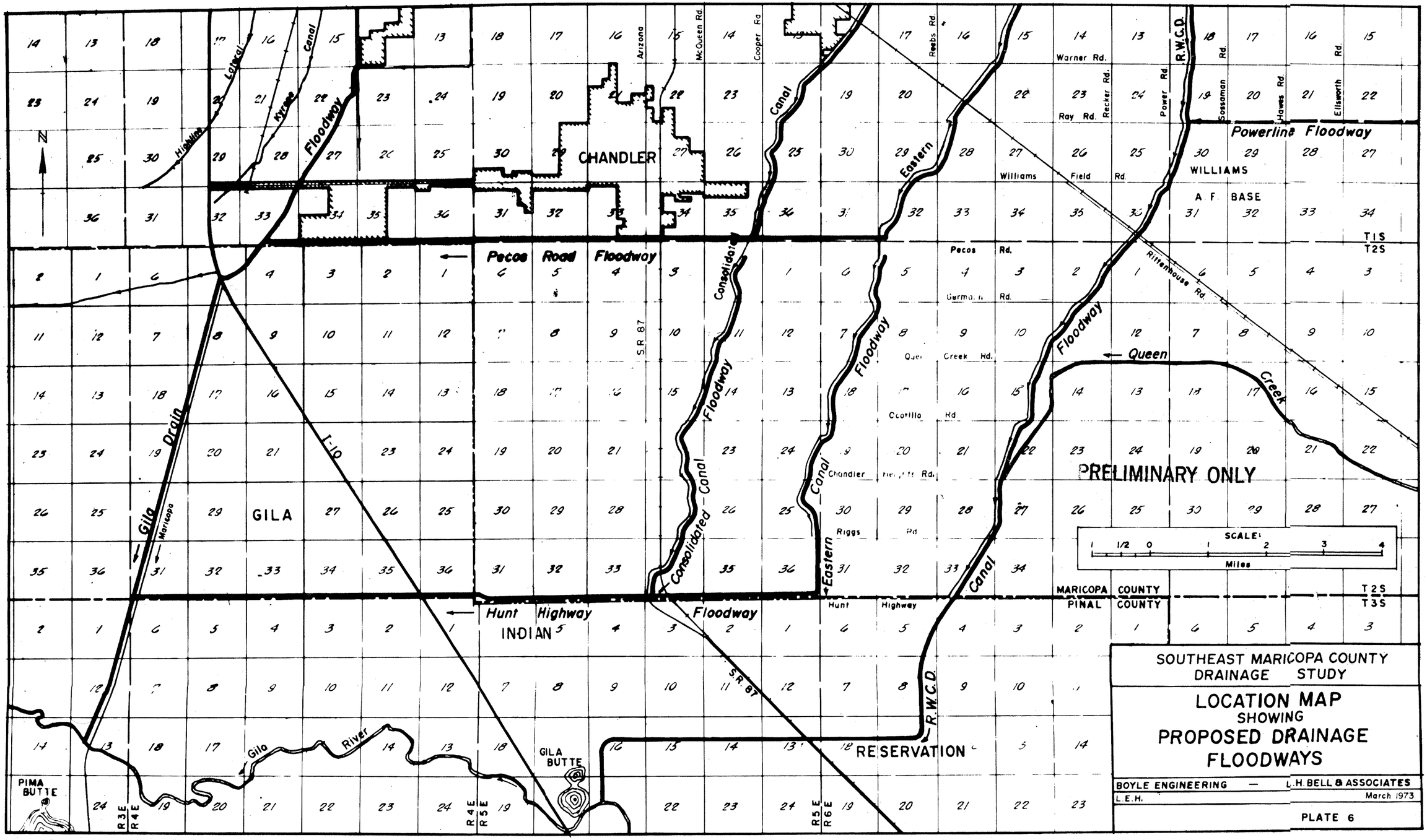
For unlined earth section channels a trapezoidal section with 2: 1 (horizontal to vertical) side slopes was assumed and an "n" value of 0.035 was used except for the floodways above the Eastern and Consolidated Canals where a value of 0.025 was used. These floodways are on very gentle slopes and have relatively small capacity requirements. Vegetation in the channel sections can be controlled more conveniently than in the larger sections.

In all unlined earth section channels it was assumed that velocities under flow conditions with the 10-year return period floods (about 43 percent of the 100-year return period peak flood flows) would be maintained at less than 6 feet per second. With the probable amounts of vegetation that would become established in these channel sections they would generally remain stable under these flow conditions. The 100-year return period flood flows would cause velocity increases of about 30 percent. However, these flow conditions would occur so infrequently and for such relatively short durations that major damages to the channel sections do not seem probable.

In areas of intensive urban development unlined earth section channels have the disadvantage of requiring relatively large areas of costly lands for right-of-way and the bridge costs for the longer spans and frequent crossings become very much larger than with a concrete lined section. In such areas a rectangular concrete lined section requires the least land for right-of-way and reduces bridge costs to a minimum. A trapezoidal concrete lined section requires more land for right-of-way and more costly bridges than a rectangular section, but considerably less than for an earth section channel.

For concrete lined channel sections an "n" value of 0.014 was used. Channel slopes were estimated from U.S.G.S. Quadrangle Sheets.


To Salt River
Spook Hill Retarding Structure
Buckhorn-Mesa Watershed
Salt River Canal
TEMPE
MESA
GILBERT
CHANDLER
Guadalupe Retarding Structure
Western Canal Floodway
Baseline Road Floodway
Pecos Road Floodway
PROPOSED SUPERSTITION FREEWAY
Apache Trail
US 60-80-89
Broadway Rd
Southern Ave
Baseline Rd.
Guadalupe Rd
Elliot Rd.
Warner Rd.
Ray Rd.
Pecos Rd.
Germann Rd.
University Dr.
Brown Rd.
McKellips Rd.
N. Dowell Rd
Hayden Rd
Mill Ave
Rural Rd
McClintock
Price Rd
Dobson Rd
Alma School Rd
Country Club Dr
Mesa Dr.
Stapley Dr.
Gilbert Rd.
Lindsay
Val Vista Dr
Greenfield Rd.
Higley Rd.
Bush Highway
56th St.
48th St
Kyrene Rd.
Kyrene Lateral Canal
Kyrene Floodway
Highline Canal
Arizona Ave
McQueen Rd.
Cooper Rd
Reebs Rd
Recker Rd.
Power Rd
Sossaman Rd
Hawes Rd.
Ellsworth Rd.
Consolidated Canal Floodway
Eastern Canal Floodway
Gila Drain
Guadalupe
GUADALUPE
R.W.C.D.
SCALE: 1 1/2 0 1 2 3 Miles
PRELIMINARY ONLY
SOUTHEAST MARICOPA COUNTY DRAINAGE STUDY
LOCATION MAP SHOWING PROPOSED DRAINAGE FLOODWAYS
BOYLE ENGINEERING — L.H. BELL & ASSOCIATES
L.E.H.
March 1973
PLATE 5



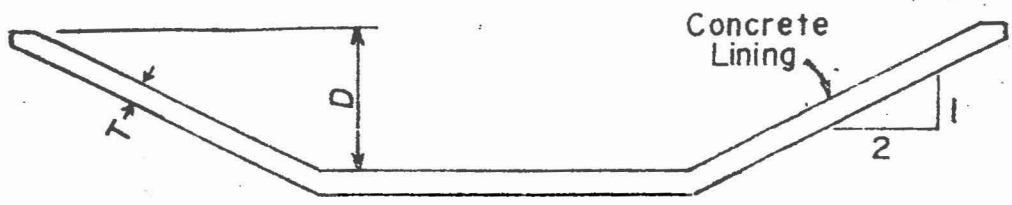
SOUTHEAST MARICOPA COUNTY DRAINAGE STUDY

LOCATION MAP SHOWING PROPOSED DRAINAGE FLOODWAYS

BOYLE ENGINEERING — L.H. BELL & ASSOCIATES

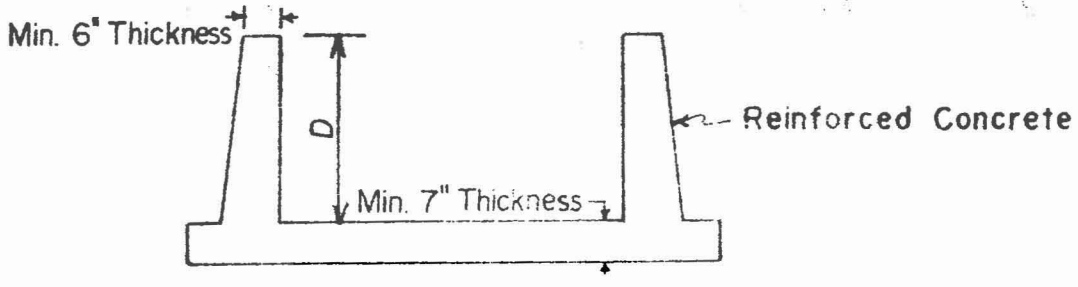
L.E.H. March 1973

PLATE 6



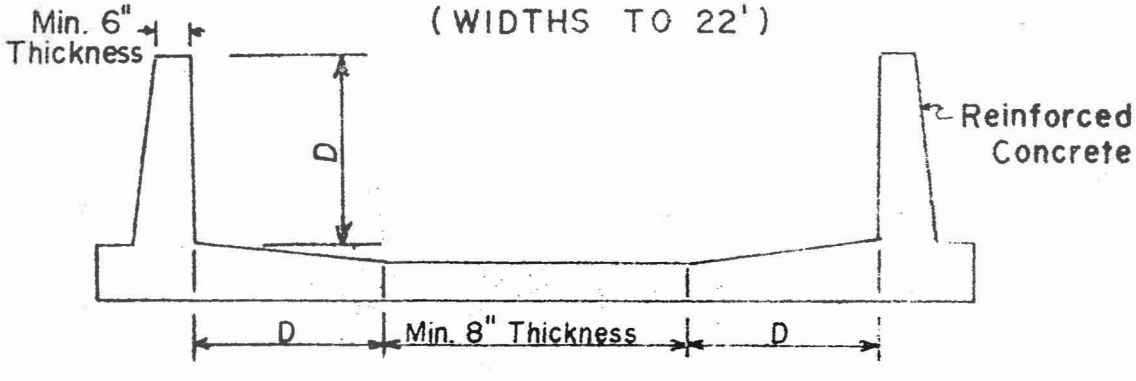
T Varies with Velocity & Whether Steel-Reinforced
(Earth Section is Identical Except for Omission of Lining)

TYPICAL TRAPEZOIDAL CHANNEL



Note: Use Non-Tapered Wall for D less than 8.5 feet.
Dimensions Vary with the Depth.

TYPICAL RECTANGULAR CHANNEL
(WIDTHS TO 22')



Dimensions Vary with Width and Depth

TYPICAL RECTANGULAR CHANNEL
(WIDTHS OVER 22')

Southeast Maricopa County
Drainage Study

TYPICAL CHANNEL SECTION

Boyle Engineering LH.Bell & Assoc.
April 1973

PLATE 7

The total costs for excavating earth section channels were estimated on the basis of 60 cents per cubic yard except for the reach of Gila Drain below the junction with Pecos Road Floodway for which 50 cents per cubic yard was used. These costs are assumed to include the costs for installation services. All costs are based on 1973 prices.

The estimated costs of lands for rights-of-way range from $2,000 per acre for agricultural lands south of Pecos Road to $11,000 per acre for land adjacent to Baseline Road.

Costs were estimated separately for the five units which compose the total system of floodways and the outlet to the Gila River:

1. Baseline Road - Western Canal Floodway, including tributary floodways above the Eastern and Consolidated Canals.
2. Pecos Road Floodway, including tributary floodways above the Eastern and Consolidated Canals.
3. Hunt Highway Drain, including tributary floodways above the Eastern and Consolidated Canals.
4. Gila Drain - Unit 1 - from its outlet into the Gila River to the boundary of the Gila Indian Reservation near its junction with the Pecos Road Floodway.
5. Gila Drain - Unit 2 - from the boundary of the Gila Indian Reservation to its upper end at the junction with Baseline Road - Western Canal Floodway near Elliot Road.

Baseline Road - Western Canal Floodway, Including Tributary Floodways

The Baseline Road - Western Canal Floodway includes 15.43 miles of channel ranging in width from 38 feet to 300 feet and in depth from 9.5 feet to 13.5 feet. Allowing 30 feet additional width for maintenance roads about 416 acres of land would be required for rights-of-way.

The tributary floodways above the Eastern and Consolidated Canals include 13 miles of

channel ranging in width for an unlined earth section from 30 feet to 85 feet and in depth from 6.0 feet to 13 feet. Allowing additional width for maintenance roads about 189 acres of land would be required for rights-of-way.

The total construction costs including installation services costs for unlined earth section channels are estimated to be $4,816,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $8,075,000 for a total cost of $12,891,000 .

The unlined earth sections on the Baseline Road - Western Canal Floodway requires extremely wide rights-of-way through a rapidly urbanizing area.

A rectangular section concrete lined channel on the Baseline Road - Western Canal Floodway would have a range of channel widths from 10 feet to 85 feet with depths ranging from 6 feet to 13 feet. About 169 acres of land would be required for right-of-way. The total construction costs for this project unit with rectangular section concrete lined channel on the Baseline Road - Western Canal Floodway and earth section on the tributary floodways are estimated to be $27,298,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $3,885,000 for a total cost of $31,183,000 .

A trapezoidal section concrete lined channel on the Baseline Road - Western Canal Floodway would have a range of channel widths from 22 feet to 110 feet with depths ranging from 6.5 feet to 14 feet. About 238 acres of land would be required for right-of-way. The total construction costs for this project unit with trapezoidal section concrete lined channel on the Baseline Road - Western Canal Floodway and earth section on the tributary floodways are estimated to be $9,171,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $5,000,000 for a total cost of $14,171,000 .

Pecos Road Floodway Including Tributary Floodways

The Pecos Road Floodway includes 10.66 miles of channel ranging in width for an unlined earth section from 58 feet to 98 feet and in depth from 8.5 feet to 12 feet. Allowing 30 feet additional width for maintenance roads about 160 acres of land would be required for right-of-way.

The tributary floodways above the Eastern and Consolidated Canals include 11 miles of channel ranging in width for an unlined earth section from 25 feet to 66 feet and in depth from 5 feet to 9 feet. Allowing additional width for maintenance roads about 146 acres of land would be required for rights-of-way.

The total construction costs including installation services costs for unlined earth section channels are estimated to be $1,724,000, and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $2,026,000 for a total cost of $3,750,000.

A rectangular section concrete lined channel on the Pecos Road Floodway would have a range of channel widths from 14 feet to 24 feet with depths ranging from 11.5 feet to 14 feet. About 44 acres of land would be required for rights-of-way. The total construction costs for this project unit with rectangular section concrete lined channel on the Pecos Road Floodway and earth section on the tributary floodways are estimated to be $13,038,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,542,000 for a total cost of $14,580,000 .

A trapezoidal section concrete lined channel on the Pecos Road Floodway would have a range of channel widths from 43 feet to 73 feet with depths ranging from 8.5 feet to 12 feet. About 101 acres of land would be required for right-of-way. The total construction costs for this project unit with trapezoidal section concrete lined channel on the Pecos Road Floodway and earth section on the tributary floodways are estimated to be $4,607,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,714,000 for a total cost of $6,321,000 .

Hunt Highway Drain Including Tributary Floodways

The Hunt Highway Drain includes 11.52 miles of channel ranging in width for an unlined earth section from 35 feet to 49 feet and in depth from 5.25 feet to 6 feet. About 103 acres of land would be required for right-of-way.

The tributary floodways above the Eastern and Consolidated Canals include 10 miles of channel ranging in width for an unlined earth section from 20 feet to 38 feet and in depth from 4 feet to 6 feet. About 123 acres would be required for right-of-way.

The total construction costs including installation services costs for unlined earth section channels are estimated to be $990,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $701,000 for a total cost of $1,691,000.

It seems improbable that concrete lined section channels would be considered for the intensity of development assumed in the hydrologic analysis.

Gila Drain - Unit 1 - Gila River to Boundary of Gila Indian Reservation

This unit of the Gila Drain includes about 9 miles of channel ranging in width for an unlined earth section from 255 feet to 358 feet and in depth from 10 feet to 14.5 feet. About 402 acres of land would be required for right-of-way.

The total construction costs including installation services costs for an unlined earth section channel are estimated to be $3,843,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,424,000 for a total cost of $5,267,000.

It seems improbable that concrete lines channel sections would be considered for this unit of the Gila Drain.

Gila Drain - Unit 2 - Boundary of Gila Indian Reservation to Junction With Western Canal Floodway

This unit of the Gila Drain includes about 5 miles of channel ranging in width for an unlined earth section from 200 feet to 205 feet and in depth from 12.5 feet to 13.5 feet. About 149 acres of land would be required for right-of-way.

The total construction costs including installation services costs for an unlined earth section channel are estimated to be $1,633,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,832,000 for a total cost of $3,465,000.

This unlined earth section channel requires extremely wide rights-of-way through this rapidly urbanizing area.

A rectangular section concrete lined channel would have a channel width of 70 feet with depths ranging from 14 feet to 15.5 feet. About 68 acres of land would be required for rights-of-way. Construction costs for this project unit with rectangular section concrete lined channel are estimated to be $12,448,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $ 807,000 for a total cost of $13,255,000 .

A trapezoidal section concrete lined channel would have a range of channel widths from 104 feet to 116 feet with depths ranging from 14.5feet to 15 feet. About 95 acres of land would be required for right-of-way. Construction costs for this project unit with trapezoidal section concrete lined channel are estimated to be $3,737,000 and the total costs for rights-of-way, bridges and relocation of utilities are estimated to be $1,144,000 for a total cost of $ 4,881,000 .

Estimated Costs for Channel Improvements to Contain the More Frequently Occurring Floods

Providing channel improvements with smaller capacities to contain the more frequently occurring peak flood flows would cost less, but the reduction in cost would be considerably less than the proportionate reduction in capacities.

Table 11 summarizes the estimated cubic yards of concrete required per linear foot of channel improvement for capacities representing the relative peak flows for the 100-, 50-, 25- and 10-year return periods. These estimates of concrete required are based on Soil Conservation Service design standards for open rectangular section concrete lined channels. These estimates were based on 100-year return period floods of 12,000 cfs and 4,000 cfs which represents the range within the Western Canal-Baseline Road Floodway.

The concrete requirements per linear foot of channel will vary with the constraints that may be applied to depths of flow because of maximum depths desired or for other reasons. In this analysis the most efficient sections in the use of concrete were used.

For the larger flows (100-year return period - 12,000 cfs) this analysis indicates that concrete requirements per linear foot of channel increase at about half the percent rate of increase of design capacities provided. For the smaller flows (100-year return period - 4,000 cfs) it is indicated that the concrete requirements increase at about one-third the rate of increase of design capacities.

There is less right-of-way requirement for the smaller channels and probably a higher unit cost for the smaller sections. However, this analysis indicates that project costs will increase at about 50 percent of the increase in design capacities provided in channel systems. This is summarized as follows in relation to the 10-year return period flood flows:

Return Period Years	Capacity Requirements Ratio to 10-Year R.P.	Estimated Project Costs Ratio to 10-Year R.P.
10	1.00	1.00
25	1.35	1.18
50	1.94	1.47
100	2.31	1.65

These relationships similarly apply to unlined earth section channel improvements.

TABLE 11

CUBIC YARDS CONCRETE REQUIRED PER LINEAR FOOT
OPEN RECTANGULAR CONCRETE LINED CHANNEL
TO PROVIDE CAPACITIES FOR FLOODS OF VARIOUS RETURN PERIODS
DEPTHS OF FLOW - FEET

Return Period Years	Q cfs	Ratio to 10-Year	d = 11.0 D/b [1]	d = 11.0 Cu. Yds. Per L.F.	d = 10.0 D/b	d = 10.0 Cu. Yds. Per L.F.	d = 9.0 D/b	d = 9.0 Cu. Yds. Per L.F.	d = 8.0 D/b	d = 8.0 Cu. Yds. Per L.F.	Most Efficient Sections D/b	Most Efficient Sections Cu. Yds. Per L.F.	Most Efficient Sections Ratio to 10-Year
100	12,000	2.31	12.6/60	2.799							12.6/60	2.799	1.59
50	10,100	1.94	12.6/53	2.628	11.5/60	2.459					11.5/60	2.459	1.40
25	7,000	1.35	12.5/39	2.275	11.4/44	2.059	10.3/50	2.064	9.2/58	2.100	11.4/44	2.059	1.17
10	5,200	1.00	12.5/31	2.079	11.4/34	1.814	10.2/39	1.759	9.1/45	1.875	10.2/39	1.759	1.00

DEPTHS OF FLOW - FEET

Years	Q cfs	Ratio to 10-Year	d = 9.0 D/b	d = 9.0 Cu. Yds. Per L.F.	d = 8.0 D/b	d = 8.0 Cu. Yds. Per L.F.	d = 7.0 D/b	d = 7.0 Cu. Yds. Per L.F.	d = 6.0 D/b	d = 6.0 Cu. Yds. Per L.F.	Most Efficient Sections D/b	Most Efficient Sections Cu. Yds. Per L.F.	Most Efficient Sections Ratio to 10-Year
100	4,000	2.31	10.2/31	1.563	9.1/36	1.554	8.0/43	1.539	6.9/52	1.691	8.0/43	1.539	1.49
50	3,400	1.94	10.2/28	1.489	9.1/32	1.456	8.0/37	1.392	6.9/45	1.531	8.0/37	1.392	1.34
25	2,300	1.35	10.1/20	1.256	9.0/23	1.230	8.0/27	1.147	6.8/32	1.206	8.0/27	1.147	1.11
10	1,700	1.00	10.1/16	1.232	9.0/18	1.201	7.9/21	1.038	6.8/25	1.035	6.8/25	1.035	1.00

1/ D = depth of channel section, including freeboard, in feet.
Channel slope = 0.002 ft/ft. All velocities less than critical.
b = width of channel, feet.

PROJECT INSTALLATION PRIORITIES

The preferred sequence for project installation to control floods in the study area is:

1. Buckhorn-Mesa P.L. 566 Project Structural Measures (Spook Hill floodwater retarding reservoir and appurtenant diversions and outlets).
2. Roosevelt Water Conservation District Floodway - progressive installation from the Gila River to Brown Road.
3. Gila Drain progressive installation from the Gila River to Western Canal Floodway
4. Baseline Road - Western Canal Floodway from its junction with Gila Drain to junction with Eastern Canal Floodway.
5. Eastern Canal Floodway to Baseline Road.
6. Consolidated Canal Floodway to Baseline Road.
7. Laterals into Western Canal Floodway from the area below the Consolidated Canal Floodway.
8. Local drains along Warner, Ray and Williams Field Roads which discharge directly into Gila Drain.
9. Pecos Road Floodway from its junction with Gila Drain to junction with Eastern Canal Floodway.
10. Eastern Canal Floodway from Baseline Road to Pecos Road Floodway.
11. Consolidated Canal Floodway from Baseline Road to Pecos Road Floodway.
12. Local drains between Pecos Road Floodway and Hunt Highway Drain which discharge directly into Gila Drain.
13. Hunt Highway Drain

This sequence for project installation is preferred on the basis that the installation of each project element will not cause damages because of unnatural concentrations of flood flows without continued control to a safe outlet. Variations from this sequence can be made to meet the requirements for immediate needs if temporary provisions are made to assure that safe outlets are provided.

INTERIM FLOOD CONTROL MEASURES

It will be some time in the future before all of the project structural measures for flood control considered in this study can be installed practically.

The Public Law 566 projects that are approved for construction can be installed as rapidly as provisions are made to meet other costs than those that are federally funded under provisions of Public Law 566, and as Public Law 566 funds become available. The completion of the work plan for a Public Law 566 project on Lower Queen Creek and obtaining approval for construction will further delay the installation of the anticipated structural measures for this project. The installation of all structural measures included in these Public Law 566 projects will provide control of major floods from the eastern part of the area to the Roosevelt Water Conservation District Canal and flood protection for the community of Guadalupe and freeway I-10 in the western part.

The major immediate need for flood control measures in the area west of the Roosevelt Water Conservation District Canal is an outlet to the Gila River for concentrations of runoff from this area. Expanding urban development is causing greatly increased amounts of runoff because of reduced infiltration rates. Other developments that are needed because of the increased population, such as the Superstition Freeway, cause concentrations of this runoff which greatly increase the damage potential if stable outlet channels with adequate capacities are not provided.

Federal assistance in providing an outlet to the Gila River and the major collector channels and floodways in the area west of the Roosevelt Water Conservation District Canal will probably be delayed for the longest period of time because of the time required for project planning, review and approval. In the interim between the present time and the completion of these structural measures temporary measures will be required to permit continued urban development and associated improvements.

The cities of Tempe and Mesa are beginning to require that any new subdivision development provide for the control and non-damaging disposal of runoff from their development. The planning of these subdivisions provides for the storage and infiltration of runoff from each residential lot on the lot and for runoff from the subdivision streets to be collected in holding reservoirs from which the water is to be pumped into available outlet channels, such as the irrigation water supply canals, at rates that can be accommodated in these outlets.

The capacity requirements on the lots and in the holding reservoirs is based on the runoff that is estimated to occur from the 50-year return period flood. The 50-year return period, 24-hour duration, precipitation intensity estimated for this area is 3.4 inches. The estimated runoff from a 7,000 square foot residential lot for this 24-hour precipitation intensity is about 1,000 cubic feet and this volume of temporary storage capacity would be required. The infiltration rates in this area range from about 0.15 inch to 0.40 inch per hour which provides the basis for estimating the area required for the storage basins.

For a one half square mile urban development temporary storage capacity of about 10 acre-feet would be required in a holding reservoir to contain the runoff from subdivision streets.

The application of this requirement to new subdivision developments would limit the uncontrolled runoff to that from the major roads at one mile and half mile intervals. This will maintain the amounts of runoff with urban development to about that which occurs with agricultural use of the land. The application of this requirement to lands under the jurisdiction of Maricopa County would help to alleviate the flood problems caused by urban development on these lands.

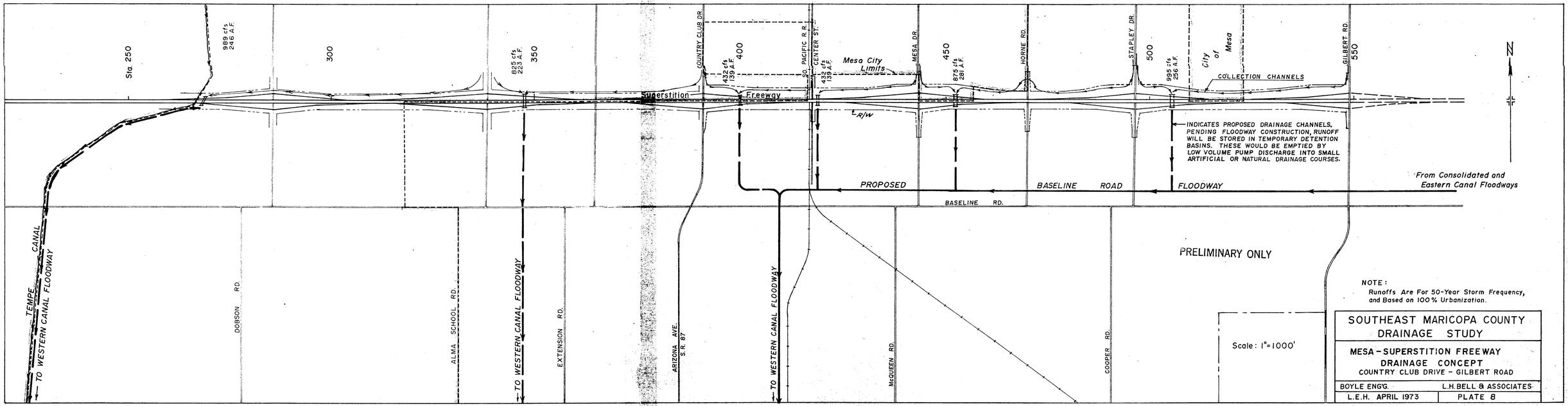
The most immediately urgent runoff problem is to provide for disposition of concentrations of runoff from the City of Mesa north of the Superstition Freeway alignment at freeway culvert crossings. With the rigid application of the requirement that new subdivision developments contain their runoff, the probability of runoff from the areas east of the Consolidated Canal breaching the

Eastern and Consolidated Canals and entering this area will not be greater than it is under existing conditions. These canals with their small protecting floodways have capacities to divert the more frequently occurring runoff without breaching.

The plan for the control of runoff after the Gila Drain and the major floodways have been installed is for the storm drainage collector system in the City of Mesa to discharge at culvert crossings through the Superstition Freeway. Superstition Freeway crossings can be provided at points where the freeway profile permits these crossings, which is generally at intervals of about one mile. Channels from these culvert crossings would connect with the Western Canal Floodway.

In the interim prior to the provision of outlet capacities in the Western Canal Floodway and the Gila Drain, the concentrations of flood flows through the freeway culverts create a disposal problem. It is proposed that an interim solution would be to collect the storm runoff on the north side of the Superstition Freeway with collector systems as they become installed or by dikes to direct the accumulated flows to the culvert crossings. The culvert outlets would discharge into channels which would terminate at temporary storage ponds. The accumulated storm runoff would be pumped from these ponds at rates which could be accommodated in the Western Canal and the Gila Drain.

Plate 8 illustrates the concept for accumulating storm runoff from the north side of the freeway at the freeway culvert crossings. Table 8 summarizes the estimated peak flood flows and volumes of runoff for concentration points at these culvert crossings for various return periods. The temporary storage ponds would have capacities to contain the volumes of runoff estimated for the flood having the return period from which full protection is considered necessary. This may vary between ponds depending upon the damage potential in the event that the capacities of the ponds were exceeded. It is probable that pond capacities should not be less than the volumes of runoff estimated for the 10-year return period flood.



NOTE:
Runoffs Are For 50-Year Storm Frequency, and Based on 100% Urbanization.

SOUTHEAST MARICOPA COUNTY
DRAINAGE STUDY

MESA – SUPERSTITION FREEWAY
DRAINAGE CONCEPT
COUNTRY CLUB DRIVE – GILBERT ROAD

BOYLE ENG'G.	L.H. BELL & ASSOCIATES
L.E.H. APRIL 1973	PLATE 8

This concept of controlling the runoff concentrations at freeway culvert crossings will permit control with temporary storage ponds to be accomplished incrementally as the freeway installation progresses.

The Gila Drain has very limited capacities under existing conditions in some reaches from the outlet of Western Canal to the Gila River. An interim improvement of the Gila Drain to contain at least the capacity of Western Canal would provide better temporary outlet conditions for natural runoff and for pumped releases from temporary storage ponds. The capacity of Western Canal is estimated at 500 cubic feet per second. Some reaches of the Gila Drain have capacities of 55 cubic feet per second or less.

When the concept of the ultimate channel system has been firmly established and rights-of-way locations are determined, interim channel improvements to contain the more frequently occurring floods may be installed to alleviate the more immediate problems.

Priorities for these interim improvements should be considered as follows:

1. Reduce the runoff from new subdivision developments by on-lot retention and accumulation of street runoff in temporary retention ponds as currently practiced by the Cities of Mesa and Tempe; and expand the application of this requirement to lands under the jurisdiction of Maricopa County. This will assist in maximizing the effectiveness of existing outlet facilities and reduce the possibility of flood flows breaching the Eastern and Consolidated Canals and entering the City of Mesa.

2. Progressive installation of facilities to control the runoff from the City of Mesa at culvert crossings as the installation of the Superstition Freeway is extended to the east.

3. Increase capacities in the Gila Drain to accommodate flows from the Western Canal.

4. Make interim improvements to relieve local flood problems within the pattern of the channel system concept for ultimate improvements.

CONCLUSIONS AND RECOMMENDATIONS

The rapid change of land use in this area from agriculture to urban causes progressively larger amounts of runoff, and the urban development increases the potential for damages when floods occur. The need for an integrated system of flood control measures to provide protection for existing development and anticipated future development is urgent.

A major part of the flood problem would be solved with the installation of the remaining structural measures included in the three Public Law 566 projects in the eastern part of the area which have been approved for construction by the Congress of the United States. These completed projects will control the runoff from the entire area east of the Roosevelt Water Conservation District Canal and discharge it through a floodway constructed above the Roosevelt Water Conservation District Canal and extended through the Gila Indian Reservation to the Gila River.

Senate Bill 1104, recently approved by the Legislature of the State of Arizona provides for making allocations from the general fund for flood control projects to pay for one-half the cost of lands, easements, and rights-of-way necessary for the construction of flood control projects adopted and authorized by the Congress of the United States and recommended by the Arizona Water Commission and approved by the Legislature as Congress makes available funds for their construction. This bill appropriates $1,350,000 for the Roosevelt Water Conservation District Floodway project and $1,000,000 for the Buckhorn-Mesa project to the Arizona Water Commission to carry out the provisions of this act. These funds in combination with local matching funds will provide a major part of costs other than those funded under provisions of Public Law 566 for the completion of these projects.

It is recommended that the procurement of rights-of-way for these projects be expedited so that their installation can be completed as rapidly as Public Law 566 funds are made available.

The Soil Conservation Service is presently developing a work plan for the lower Queen Creek project to provide a floodwater retarding reservoir to control the runoff from the drainage area of Queen Creek below Whitlow Dam. The installation of measures considered for inclusion in this project would complete the control of runoff from the entire area east of the Roosevelt Water Conservation District Canal between the Salt River and the Gila River.

It is recommended that the Soil Conservation Service be urged to expedite the completion of the lower Queen Creek watershed work plan.

The Guadalupe Public Law 566 Project has been approved for construction by the Congress of the United States and rights-of-way are presently being procured.

It is recommended that completion of rights-of-way procurement be expedited and that the Soil Conservation Service be urged to proceed with installation of the project measures.

This study has indicated the engineering feasibility of controlling the runoff from the area west of the Roosevelt Water Conservation District Canal with a combination of collector systems and floodways discharging into an outlet to the Gila River. The major elements of this system include a floodway along Baseline Road and Western Canal alignment; a floodway along Pecos Road; and a floodway along Hunt Highway; all discharging into a common outlet designated as the Gila Drain to the Gila River. These projects are of such magnitude that federal assistance may be obtained through the flood control assistance programs of the Corps of Engineers and the Soil Conservation Service.

It is recommended that these potential projects be discussed with representatives of the Corps of Engineers and the Soil Conservation Service. On the basis of these discussions it should be

determined from which agency assistance should be requested for all or parts of the needed improvements. It may be that assistance from both agencies may be requested based upon an appropriate division of the area.

The project elements were formulated on the basis of providing capacities to contain the runoff estimated to occur with the 100-year return period floods under conditions of anticipated urban development. Estimates of installation cost were made for unlined earth section channels and for concrete lined channels with rectangular and trapezoidal sections. The least capital cost for improvements is required for unlined earth section channels. However, operation and maintenance costs are much higher for earth-section channels than for concrete lined channels, greater widths of land for right-of-way are required and bridge costs are much larger because of the longer spans required.

It is recommended in project development that all of these factors be considered especially for presently or anticpated intensively urbanized areas where frequent bridge crossings are required and the relatively wide earth section channels may have an adverse environmental impact.

In the hydrologic analysis for this study runoff was estimated for the 100-year return period flood and other return periods for some areas under specified conditions of anticipated urban development. This was accomplished using the Soil Conservation Service computer program, TR-20, Hydrology for Project Formulation. In the interim between the present and the time that the ultimate projects are installed interim improvements may be required to control the more frequently occurring floods under condtions of urban development varying from those used in this study.

It is recommended that the Flood Control District of Maricopa County obtain the computer program, TR-20, Hydrology for Project Formulation for use with the County's IBM 1130 computer. With the parameters established in this study for hydrologic analysis adjustments can be made to obtain runoff estimates for other return periods and intensities of urban development.

Interim improvements will be required between the present and the time that the ultimate projects are installed to permit the continuing development of the area.

At present the cities of Mesa and Tempe are requiring that new developments require the containment of runoff from individual residential lots on the lots until it infiltrates or evaporates; and the runoff from subdivision streets in ponds to be disposed of at rates compatible with the capacities of existing outlet facilities. These requirements tend to neutralize the effects of urban development in increasing runoff to outlet channels.

It is recommended that Maricopa County establish similar requirements for urban development on county lands.

The development of the Superstition Freeway could continue without causing increased flood damages due to concentrations at culvert crossings if these flood volumes were temporarily stored in ponds and released at rates compatible with capacities of existing outlet channels.

It is recommended that the City of Mesa and the State Highway Department obtain agreement with regard to responsibilities for the disposal of these flood volumes as to permit the continued construction of the Superstition Freeway.

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GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO

INTERIM REPORT

ON

SURVEY FOR FLOOD CONTROL

PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)

(WITH APPENDIXES)

U. S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS

JANUARY 15, 1964

10

INTERIM REPORT OF THE DISTRICT ENGINEER
ON SURVEY FOR FLOOD CONTROL

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

SYLLABUS

This interim report, submitted pursuant to act of Congress, Public Law 761, 75th Congress, approved June 28, 1938, considers the flood problems in the Phoenix, Ariz., metropolitan area.

The district engineer finds that a serious flood problem exists along Dreamy Draw, Cave Creek, and Skunk Creek, and along the New and the Agua Fria Rivers where intensively developed urban and agricultural areas within and adjacent to the city of Phoenix are subject to damage. The flood channels of Dreamy Draw and Cave Creek disappear at the Arizona Canal and not even a trace of a stream is evident downstream. The area downstream from the canal is now intensively developed with urban-type property - predominantly residential, commercial, and industrial improvements. Floods along Skunk Creek and along the New and the Agua Fria Rivers cause damage mostly to agricultural-type property, except in the communities of Peoria and Avondale. Because of the continued rapid growth in the overflow area, damages under future conditions will be considerably greater than under present conditions.

After consideration of the plans proposed by local interests, the district engineer - in cooperation with the Flood Control District of Maricopa County - developed a comprehensive flood-control plan for the Phoenix metropolitan area to serve as a framework for all flood-control work in the area. A report covering phase A of that plan - comprising a flood channel along Indian Bend Wash from the Arizona Canal to the Salt River - was completed April 15, 1962. The district engineer now finds that economically feasible protection can be provided by the construction of phase B of the comprehensive plan, comprising (1) the Cave Creek, the Skunk Creek, the New River, and the Dreamy Draw Dams; (2) the Union Hills and the Arizona Canal diversion channels; and (3) the Cave Creek, the Dreamy Draw, the Skunk Creek, the New River, and the Agua Fria River channel improvements. He finds that the proposed plan of improvement would prevent about 89 percent of the potential damage in the area.

The district engineer estimates the total Federal first cost of the project at $59,680,000 (October 1963 prices) for construction and the total non-Federal first cost at $11,120,000 (October 1963 prices).

He estimates the total average annual charges at $2,740,000, including an average charge of $228,000 annually for maintenance and operation of the improvements. He estimates the average annual benefits that would accrue from the prevention of flood damages and from the increased utilization of land at $8,210,000. He estimates that the ratio of average annual benefits to average annual charges would be 3.0 to 1 on the basis of tangible benefits alone. Intangible benefits would add weight to the justification.

The district engineer recommends that the United States adopt a project for the control of floods along Cave and Skunk Creeks and along the New and the Agua Fria Rivers within the metropolitan area of Phoenix, Ariz., as previously described, subject to the condition that local interests supply assurances satisfactory to the Secretary of the Army that they will provide - without cost to the United States - all lands, easements, and rights-of-way necessary for the construction and subsequent maintenance and operation of the project at a cost estimated at $7,320,000; perform - without cost to the United States - all necessary construction or relocation of highways, roads, bridges, utilities, and all necessary street modifications required in connection with the project, at a cost estimated at $3,800,000; hold and save the United States free from damages due to the construction works; maintain and operate all the works, after completion, in accordance with regulations to be prescribed by the Secretary of the Army, at an average annual cost estimated at $228,000; prevent any encroachment upon the improved channels or within the detention-basin areas that would reduce their flood-conveying or storage capacities; and hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the project.

The district engineer further recommends that the recommended detention basins be modified to provide fish-and-wildlife and recreational facilities upon the finding of economic justification by the Corps of Engineers in cooperation with appropriate State and Federal agencies.

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4.	Benefits from flood control.
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6.	Resolution by local interests.

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES,
CORPS OF ENGINEERS,
OFFICE OF THE DISTRICT ENGINEER,
Los Angeles, Calif., January 15, 1964.

Subject: Interim report on survey for flood control, Phoenix, Ariz., and vicinity (including New River), Gila River basin, Ariz.

Through: The Division Engineer, U.S. Army Engineer Division, South Pacific, San Francisco, Calif.

To: The Chief of Engineers, Department of the Army, Washington, D.C.

AUTHORITY

1. This report is submitted pursuant to act of Congress, Public Law 761, Seventy-fifth Congress, approved June 28, 1938, which reads in part as follows:

> SEC. 6. The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control including floods aggravated by or due to tidal effect at the following-named localities, * * *:
>
> * * * * * * *
>
> Gila River and tributaries, Arizona and New Mexico.
>
> * * * * * * *

2. The survey for the Gila River basin is being covered by means of interim reports, review reports, and a final comprehensive report. Seven interim reports have been submitted to Congress, as follows: (a) Tucson, Ariz., and vicinity, dated November 20, 1945; (b) Queen Creek, Ariz., dated February 2, 1946; (c) Gila River and tributaries below Gillespie Dam, Ariz., dated September 1, 1948; (d) lower Agua Fria River and vicinity, Arizona, dated December 10, 1952; (e) Gila and Salt Rivers, Gillespie Dam to McDowell damsite, Arizona, dated December 4, 1957; (f) Gila River with particular reference to a dam at or near the Camelsback site, Arizona, dated May 1, 1960; and (g) Pinal Creek and tributaries, Arizona, dated September 15, 1961. Three review reports have also been submitted to Congress, as follows: (a) Gila River, Camelsback Reservoir site to Salt River, Ariz., dated December 31, 1957; (b) Tucson, Ariz., and vicinity, dated January 26, 1959; and (c) Gila River and tributaries downstream from Painted Rock Reservoir, Ariz., dated April 1, 1961.

3. Two interim reports have been completed by the U.S. Army Engineer District, Los Angeles, and are being processed for submission to Congress, as follows: (a) Indian Bend Wash, Ariz., dated April 15, 1962, and (b) Santa Rosa Wash, Ariz., dated August 1, 1962. Work on an interim report for Willcox, Ariz., and vicinity is under way.

4. This interim report considers the Phoenix metropolitan area. The final comprehensive report for the entire Gila River basin will include summaries of findings and conclusions in all interim and review reports, consideration of problems in areas not covered in any interim report, and analysis of the interrelation of problems and plans of improvement in all parts of the Gila River basin.

SCOPE

5. Geographical scope.--The Flood Control Act of June 28, 1938, authorized an investigation for flood control in the entire drainage area of the Gila River and tributaries, Arizona and New Mexico. On the basis of the authorization in that act, the Chief of Engineers, on November 20, 1958, authorized an interim investigation limited to the New River, Ariz., and then on October 16, 1959, authorized an interim investigation of Phoenix, Ariz., and vicinity - combining it with the interim investigation on the New River.

6. Investigations described in this interim report were made to (a) develop a comprehensive plan that will serve as a framework for all flood-control work in the Phoenix metropolitan area and (b) develop in detail that part of the comprehensive plan under which protection would be provided for areas along Cave Creek, Dreamy Draw, unnamed washes in Deer Valley, Skunk Creek, the New River, and the Agua Fria River - all of which have urgent flood problems. The plan of improvement recommended in the interim report for Indian Bend Wash, Ariz., would be a part of the comprehensive plan. A field inspection of the Phoenix area was made by the district engineer.

7. Functional scope.--Primary consideration was given to the need for flood control and the solution of flood problems. Water-conservation features could not be developed because of the inadequacy of flow in the area. The development of hydroelectric power was not considered because the runoff from the relatively dry drainage areas considered in this report, combined with the high evaporation rate, would produce power of a negligible amount and of a highly intermittent nature

8. Recreation and fish-and-wildlife aspects were considered in the studies for this project.

PRIOR REPORTS

9. Interim and review reports submitted or under preparation as portions of a final comprehensive report of the entire Gila River basin are listed under a preceding heading, "Authority." Of these reports, the report on Indian Bend Wash, Ariz., now nearing completion, and the report on Gila and Salt Rivers, Gillespie Dam to McDowell damsite, Arizona, dated December 4, 1957 (see H. Doc. 279, 86th Cong., 1st sess.), cover the Phoenix metropolitan area. Pertinent information on each of these reports is given in the following subparagraphs.

(a) Indian Bend Wash, Ariz.--The report on Indian Bend Wash, Ariz., recommends construction of a channel improvement along Indian Bend Wash from the Arizona Canal to the Salt River to control all floods up to and including 40,000 cubic feet per second.

(b) Gila and Salt Rivers, Gillespie Dam to McDowell damsite, Arizona.--The improvements recommended in the report on Gila and Salt Rivers, Gillespie Dam to McDowell damsite, Arizona, were authorized by the Flood Control Act of July 14, 1960. The project includes. (1) levees along the Salt River in the vicinity of Phoenix and Tempe, Ariz.; (2) cleared floodway along the Salt and Gila Rivers between Granite Reef Dam and Gillespie Dam; and (3) low-flow channels along parts of the cleared floodway.

(c) Recent studies by the Bureau of Reclamation, in cooperation with the Corps of Engineers, indicate the economic justification of a multiple-purpose reservoir at the Maxwell site (formerly called McDowell) on the Salt River, just below the mouth of the Verde River. With construction of this reservoir, levees along the Salt River, as authorized by the 1960 Flood Control Act, are no longer required.

(d) The improvement of the Gila River, from the mouth of the Salt River to Gillespie Dam, would assist in carrying flows conveyed by the plan of improvement recommended in this report through the agricultural area along the Gila River.

10. One of the streams under investigation in this interim report is the Agua Fria River, which is in the vicinity of Phoenix. Floodflows on Trilby Wash are controlled by McMicken Dam, and resultant outlet discharges are conveyed to the Agua Fria River - as recommended in the interim report on the lower Agua Fria River and vicinity, Arizona, dated December 10, 1952 (see Committee Print dated March 30, 1953, 83d Cong., 1st sess.). Trilby Wash flows have only a minor effect on flows considered in this interim report.

DESCRIPTION

11. Location and extent.--The Gila River basin, the largest drainage area tributary to the lower Colorado River, includes the

southern half of Arizona and a part of southwestern New Mexico. The drainage area of the basin comprises about 58,200 square miles - comprising 5,600 in New Mexico, 51,500 in Arizona, and 1,100 in Sonora, Mexico.

12. The Salt River basin, with a drainage area of 16,040 square miles, and the Agua Fria River basin, with a drainage area of 2,340 square miles, contribute to the flood problem in the Phoenix metropolitan area. The comprehensive plan of improvement would provide for the control of the Salt River, the Agua Fria River, and their major tributaries in the Phoenix metropolitan area (an area of more than 500 square miles including - in addition to the city of Phoenix - the cities and communities of Mesa, Tempe, Scottsdale, Glendale, Peoria, Avondale, and Tolleson).

13. That part of the drainage area considered in this interim report comprises the following areas involved in urgent flood problems in metropolitan Phoenix: The drainage area of Cave Creek (270 square miles); the drainage area of the Agua Fria River and its tributaries, the New River and Skunk Creek (2,340 square miles); and the drainage areas of several small unnamed tributaries draining into the Salt River from the north at Phoenix (120 square miles). Those drainage areas, which are in Maricopa and Yavapai Counties in south-central Arizona, have a north-south length of about 80 to 90 miles and an east-west width of about 20 to 25 miles. (See index map, pl. 1, at the end of the main report.)

14. Streams.--Pertinent information on the streams considered in detail in this interim report is given in the following subparagraphs.

(a) Agua Fria River.--The Agua Fria River, the largest stream studied in this report, will serve as an outlet for all water proposed to be diverted from the Phoenix metropolitan area. This report is only concerned with that part of the Agua Fria River below the mouth of the New River, a distance of about 10 miles.

(b) The Agua Fria River rises about 7,000 feet above sea level in the mountains of central Arizona and flows southward for about 130 miles before emptying into the Gila River about 4 miles downstream from the mouth of the Salt River, at elevation 910 feet. The course of the stream is about equidistant between two parallel mountain ranges that form the eastern and western boundaries of the drainage area. Tributaries, except for the New River, are generally short.

(c) New River.--The New River, the major tributary of the Agua Fria River, rises in the New River Mountains about 40 miles north of Phoenix and flows generally southward for about 40 miles to its confluence with the Agua Fria River, about 15 miles west of Phoenix. Its drainage area is 350 square miles.

(d) Skunk Creek.--Skunk Creek, the major tributary of the New River, rises in the New River Mountains about 35 miles north of Phoenix and flows generally southwestward for about 30 miles to its confluence with the New River about 15 miles northwest of Phoenix. The drainage area is 140 square miles.

(e) Cave Creek.--Cave Creek rises in the New River Mountains and flows generally southward for about 48 miles, passing through the center of Phoenix before entering the Salt River. The drainage area is 270 square miles.

(f) Dreamy Draw.--Dreamy Draw, a tributary of Cave Creek, rises in the Phoenix Mountains and flows generally southeastward for about 5 miles to its confluence with Cave Creek in Phoenix. The drainage area is 5 square miles.

(g) Other streams.--Several small, unnamed washes between the Agua Fria River and Cave Creek rise on the broad alluvial cone between those two streams, not more than 10 miles north of the Salt River, and flow generally southward through an area west of Phoenix to the Salt River.

15. The Salt River, a major tributary of the Gila River, flows through Phoenix. Although detailed consideration in this report is not given to the Salt River, it now serves as the main outlet channel for Cave Creek and other relatively minor washes described in the preceding paragraph.

16. Stream characteristics.--In general, stream slopes are steep in the mountains, resulting in high-velocity flows that cut deep, well-defined channels. On the moderate slopes of the valley plains, the material cut from the mountains has been redeposited in alluvial cones with poorly defined channels adequate for only small flows. In addition, where urban development has taken place, the stream channels have been almost entirely eliminated by street and subdivision grading. Surface flow in all streams considered in this report is intermittent and usually occurs only after heavy precipitation.

17. The natural channels of Cave Creek, Dreamy Draw, and of the washes west of Cave Creek have been obliterated by development in the reaches just downstream from the irrigation canals. Skunk Creek, the New River, and the Agua Fria River still retain their natural channels, each of which has a nondamaging capacity of about 1,000 cubic feet per second. During times of potential flooding, the irrigation canals are operated so that they may intercept floodflows. The Arizona Canal can intercept floodflows ranging from 600 to 1,500 cubic feet per second and the Grand Canal can intercept floodflows of about 600 cubic feet per second. When runoff exceeds that amount, flows are discharged over spillways or breaks occur in the south banks of the canal, flooding the area downstream.

18. Topography.--Elevations in the drainage areas considered in detail in this report range from about 1,000 feet at the Salt River to about 7,000 feet in the headwaters of the Agua Fria River. The mountains north of Phoenix rise to an elevation of about 5,000 feet. The valley region is characterized by short rugged mountains and broad intermountain alluvial plains.

19. Geology and soils.--The rocks in the mountains of the headwaters of the streams are schists, granites, and volcanics. The volcanics consist of basalts, tuffs, and agglomerates. Some of the outlying ridges and hills are composed of greenstone.

20. A large part of the area is covered by alluvial deposits of a great but undetermined thickness. Deep holes drilled at various places in the lower valleys have penetrated up to 1,000 feet or more of valley fill below the surface of the alluvial plain. Rocks of a character similar to those of the adjoining mountain ranges probably underlie the alluvial deposits.

21. The deep dissection of the valleys in the mountains and the great extent of the alluvial aprons suggest that the area under consideration has had a long, stable history. Although considerable evidence of ancient folding and faulting is seen in the outcrops of the older rocks, no recent seismic activity in the area under consideration is recorded.

22. The alluvial materials in the streambeds are mostly sand and gravel that contain cobbles and some boulders near the mountains. The alluvial materials in the valleys are mostly sand and silty sand that contain varying amounts of caliche.

23. Vegetation.--Natural vegetation in the area is sparse. Cactus, creosote bush, sagebrush, and paloverde are the dominant desert plants. Irrigation canals and wells that serve much of the plain area have permitted development of productive farmland and landscaped residential tracts.

ECONOMIC DEVELOPMENT

24. Population.--The principal population centers affected by improvements considered in detail in this report are the city of Phoenix, the town of Peoria on the New River, and the town of Avondale on the Agua Fria River. The population in the general area is increasing at a tremendous rate. Population estimates for the city of Phoenix and for Maricopa County for the years 1940, 1950, 1960, and 1963 are given in the following table. Shown also is the growth of the incorporated area of the city of Phoenix.

Year	Incorporated area - city of Phoenix.	Population	
		City of Phoenix	Maricopa County
	Square miles		
1940*.....	9.6	65,400	186,200
1950*.....	17.1	106,800	331,770
1960*.....	187.4	439,200	663,500
1963**.....	222.6	503,600	847,500

* U.S. Census estimates.

** Estimate for March 1963 made by Planning and Zoning Department, Maricopa County.

25. The preceding table shows that the population of the city of Phoenix increased by about 310 percent from 1950 to 1960 and by nearly 15 percent during the 3-year period from 1960 to 1963. The growth of Maricopa County is equally impressive. The Valley National Bank, which maintains a highly regarded statistical department, estimates that the population of Maricopa County will be 2,000,000 by 1980. The growth of the incorporated area of the city of Phoenix should be noted - this growth from 1950 to 1963, a 13-year period, amounted to 1,200 percent. This growth, which resulted in the conversion of agricultural and desert properties to urban uses, is one of the principal reasons for the aggravation of the flood problem in the Phoenix area. (For additional information on population and growth, see appendix 4.)

26. Occupations and industries.--The percentage distribution of the labor force in Maricopa County for 1958 and 1980, as estimated by Western Business Consultants, Inc., is given in the following table:

Occupation	Estimated percentage distribution of labor force	
	1958	1980
Agriculture.....	12	5
Contract construction and mining.....	8	8
Manufacturing.....	13	24
Transportation, communication, and public utilities.....	6	5
Wholesale trade.....	5	6
Retail trade.....	19	18
Finance, insurance, and real estate.....	5	5
Service.....	16	16
Government (civilian and military).....	16	13
Total.....	100	100

27. Continued industrialization is shown by the decline in agriculture and the large increase in manufacturing. Several major plants have located in the Phoenix area since World War II, notably the General Electric Computer plant, the Reynolds Aluminum extrusion plant, the Motorola Electronics center and research laboratory, and the Sperry Rand Company. Tourism has always been important in Phoenix and adjacent areas because of the favorable winter climate and the picturesque surroundings. Tourist accommodations are available for more than 35,000 people, and many excellent restaurants and nightclubs are available for dining and entertainment needs. Agriculture in the Phoenix area, which has been the dominant industry in the past, is assuming a lesser role in the economy of the area.

28. Land use and development.--The Reclamation Act of 1902 and the subsequent authorization and construction of the Salt River project paved the way for development in the Phoenix area. The Salt River project includes an area of about 240,000 acres, supplied with water from the Salt and Verde Rivers and from about 270 wells that tap the underground basin. The two rivers are controlled by six storage dams (Roosevelt, Horse Mesa, Morman Flat, and Stewart Mountain Dams on the Salt River and Horseshoe and Bartlett Dams on the Verde River). The total capacity of the six reservoirs is about 2,100,000 acre-feet; Roosevelt Reservoir is the largest with a capacity of about 1,380,000 acre-feet. The Granite Reef diversion dam, located about 3 miles below the junction of the Salt and Verde Rivers, serves lands on both sides of the Salt River by diversion to the Arizona Canal on the north side and the South Canal on the south side. Other subsidiary canals divert from these two main canals. The Arizona Canal, which is the high line canal on the north side, is involved in this report. It is about 38 miles long and has a diversion capacity of 2,000 cubic feet per second. In the vicinity of Cave Creek, the Arizona Canal has a capacity of 600 cubic feet per second.

29. The amount of project land under cultivation in the Salt River project reached a high of 227,000 acres in 1940. After Work War II, however, agriculture began to decline with the tremendous shift to urbanization and industrialization. The area under cultivation in the Salt River project in 1962 amounted to only 146,300 acres, a decline of 35 percent from the 1940 acreage. Estimates prepared in 1958 indicated that the Phoenix urban land area was about 52 percent developed, 29 percent vacant, and 19 percent agricultural. The area along the New River remains predominantly agricultural; however, its nearness to Phoenix makes it ripe for urban development in the near future and its present value reflects its prospective use for residential and commercial purposes.

30. Water and power.--Water is supplied to the Phoenix urban area by four municipal systems (Phoenix, Glendale, Tempe, and Mesa), by the Salt River project, and by several private franchise companies. The municipal systems serve the areas of urban concentration, and the Salt River project and private companies serve scattered outlying

developments. Irrigation water for agriculture is obtained either from the Salt River project canal system or by pumping from the underground water basin. Electric power is supplied by the Salt River project and from the Arizona Public Service Company.

31. Transportation facilities.--The Phoenix area is served by an adequate net of local, State, and transcontinental highways. Recent major street and highway improvements include an extensive freeway system in the immediate Phoenix area. That system has been integrated with the transcontinental highways now passing through the area. Both the South Pacific and the Santa Fe Railroads serve Phoenix. Four major air facilities, one municipal and three military, are within 25 miles of Phoenix. A multimillion-dollar expansion program was recently completed on Sky Harbor Airport, the municipal facility that provides complete local and transcontinental air service.

CLIMATOLOGY

32. General.--Phoenix has an arid subtropical climate with a frost-free growing season of about 280 days. Winters are mild with clear days and cool nights. Average wind velocities are low to moderate except that high gusty winds may accompany thunderstorms, usually occurring during July and August. U.S. Weather Bureau records for Phoenix indicate a long-term average temperature of about 70 degrees Fahrenheit, with the temperature ranging from 17 degrees Fahrenheit in winter to 118 degrees Fahrenheit in summer. Winter storms bring some rain, however, usually in light amounts. Summers are hot, with daily temperatures over 100 degrees being common. Summer thunderstorms of high intensity but short duration bring most of the annual rainfall. Even these amounts are usually small; the greatest average monthly rainfall is 1.06 inches, occurring in August.

33. Precipitation records.--Precipitation records are available for approximately 55 rainfall stations in and near the drainage areas considered in this report. The longest record in the general area is for the Phoenix Post Office, with 86 complete years of record during the period 1876 to 1962, inclusive. Five recording gages are also in the area, the longest record (beginning in 1901) being also for the Phoenix Post Office. The 90-year mean annual precipitation for stations in the general area, with records of more than 5 complete years, ranges from 7.26 inches per year at Phoenix Indian School, in the city of Phoenix, to 11.71 inches per year at Bartlett Dam, about 35 miles northeast of the center of Phoenix. The 90-year mean annual precipitation is about 7.4 inches in downtown Phoenix, about 9.7 inches at existing Cave Creek Dam, and about 24 inches in the upper part of the drainage area, with an average of about 14.5 inches for the general area.

34. Storms.--Three types of storms produce rain in the Phoenix area: general winter storms, general summer storms, and local summer thunderstorms. General winter storms are the result of weather fronts passing through the area from the Pacific Ocean. Because these fronts must first pass over the coastal mountains, much of their moisture has been lost by the time they reach the Phoenix area. They reflect an orographic influence in their passage and are of low intensity that may last several days. The general winter storms, which occur between November and April, frequently cover the entire Gila River basin. Flooding along the larger washes and rivers can result from these storms but does not usually occur in the smaller drainage areas because of the low rainfall intensity.

35. In late summer or early fall, tropical storms originating along the Mexican Pacific coast or the Gulf of Mexico can reach the Gila River basin, producing the general summer storm with heavy precipitation in large areas. They reflect orographic influence and can cause flooding along small washes or large rivers.

36. The third type, local summer thunderstorms, is common in the months of July through October but can occur at any time of year. They cover comparatively small areas and are of high intensity but short duration, usually 3 hours or less. They produce many of the destructive flash floods, well known in the southwest.

RUNOFF AND STREAMFLOW DATA

37. General.--No adequate runoff records are available for the drainage areas studied in detail in this report. Two stream gages were installed recently: one in October 1957 on Cave Creek at Phoenix about one-half mile upstream from the Arizona Canal and the other in December 1960 on the New River at the Black Canyon Highway. No consistent or usable record is available for the existing Cave Creek Dam. Records are available for Lake Pleasant Reservoir on the Agua Fria River for 34 years. However, because of elevation and other drainage-area characteristics, the Agua Fria drainage area above Lake Pleasant is not typical of the drainage areas of immediate concern in the investigations for this report.

38. Adequacy of streamflow for multiple-purpose uses.--Little streamflow occurs in any of the streams considered in this report, except during and immediately following periods of heavy rainfall. The climatic and drainage area characteristics of this relatively dry, low-average-rainfall drainage area with its high evaporation rate are not conducive to continuous runoff.

FLOODS

39. Floods of record.--Only incomplete and fragmentary data are available regarding past floods along Cave Creek, along the New River and the Agua Fria River, and in the tributary drainage areas. Data on past floods in the Cave Creek drainage area and along the New River were submitted at the public hearing held in 1959. These data came from newspaper files and from the files of the irrigation districts and water-user associations in the area. Data for the Agua Fria River were compiled from U.S. Geological Survey Water Supply Papers and other records. The following subparagraphs summarize the flood history for the three streams.

(a) Cave Creek.--Large floods are known to have occurred along Cave Creek in February 1905 and August 1921; small to medium floods in September 1916, November 1919, January 1922, and August 1943; and minor floods in 1935, 1949, 1951, 1952, and 1957. No reliable estimate, however, is available of any of the floods of record.

(b) Floodflows also originate from the unnamed washes draining the slopes of the mountains east of Cave Creek and just north of the Arizona Canal in the Sunny Slope-Dreamy Draw area. When such floodflows were large enough to breach the Arizona Canal, they became a matter of newspaper record. Because runoff from this area does not concentrate in any one stream channel, estimates of discharge from any single flood are not available. However, the size and number of breaks in the canal serve as a measure of the relative magnitude of these floods. Using this criterion, the floods of July 1911 and of August 1943 are estimated to be large floods, and the floods of July 1936 and of September 1939 are considered to be medium floods. In addition, minor floods were reported in 1955, 1959, and 1961.

(c) New River.--Quantitative flood records for the New River are meager. The largest flood of record, with an estimated discharge of 38,000 cubic feet per second measured at the highway bridge at Peoria, occurred in August 1943; medium-sized floods were reported in August 1951, July 1955, January 1957, and July 1957. The peak discharge of the July 1955 flood was estimated at 12,000 cubic feet per second. Small floods were reported in June 1955 and October 1956.

(d) Agua Fria River.--The Agua Fria River has a much more complete record of floods. Two floods, one in January 1916 and another in November 1919, were the largest of record; each is estimated to have had a discharge of 105,000 cubic feet per second

at Avondale. Since 1889, the records indicate five large floods within the range from 50,000 to 80,000 cubic feet per second, four floods within the range from 30,000 to 50,000 cubic feet per second, and three floods within the range from 10,000 to 30,000 cubic feet per second. During that period, eleven additional floods were reported but without any indication of relative size.

(e) Lake Pleasant Reservoir, a water-conservation reservoir with a capacity of 163,800 acre-feet (1962), was built by the Maricopa County Municipal Water Conservation District No. 1 (Beardsley Project) in 1928. Since that date, one spill has occurred, on April 19, 1941, when 500 acre-feet were discharged over the spillway.

40. Flood characteristics.--Most floods in the drainage areas under consideration are of the flash-flood type resulting from thunderstorm rainfall that occurs unexpectedly, with little or no time to warn affected communities of impending danger that may result in loss of life and damage to property. However, flooding can also occur from either general summer storms or general winter storms over the area. Duration of flooding from thunderstorms rarely lasts more than a few hours. Little streamflow occurs except immediately following the heavier rains because climate and drainage-area characteristics are not conducive to continuous runoff.

41. Because of steep gradients, streamflow in the mountains increases rapidly in response to high-intensive rainfall and causes high-peak debris-laden floods to debouch onto the valley plains below. As the flow reaches the valley plains, it spreads out as overland flow, and a considerable amount of flow is lost to streambed percolation. The stream channels are generally poorly defined and are adequate to accommodate only minor flows. The percentage of impervious area, especially in the lower reaches of the drainage basin, is increasing appreciably because of the urban developments taking place. Vegetation, being sparse, has a negligible effect on flood runoff.

42. Flood frequencies.--Because of the lack of adequate streamflow data for streams in the drainage areas under detailed consideration in this report, discharge-frequency curves were developed by utilizing (a) the incomplete data that were available and (b) the discharge-frequency curve previously developed for Whitlow Ranch Dam on nearby Queen Creek, after making adjustments to reflect differences in drainage-area characteristics. Discharge-frequency curves for Cave Creek and the New River and more detailed information on their development are included in appendix 4. The estimated frequencies of uncontrolled floods of various magnitudes for Cave Creek and the New River are listed in the following table:

Estimated flood frequencies, Phoenix, Ariz., and vicinity (including New River)

Number of times that flow would be equalled or exceeded in 100 yrs.	Uncontrolled peak discharges	
	Cave Creek at Arizona Canal	New River at Highway 60 bridge
	Cubic feet per second	Cubic feet per second
0.23	*65,000	*126,000
1.00	29,500	58,000
2.00	19,500	38,000
5.00	10,500	20,500
9.00	6,400	13,000
10.00	6,000	11,500
15.00	4,000	8,000
20.00	3,000	6,000
35.00	1,500	3,000
45.00	1,000	2,000
58.00	**600	.....
64.00	.....	**1,000

* Standard project flood under natural conditions.
** Nondamaging.

43. Standard project flood.--A standard project flood is an estimated or hypothetical flood that might be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical region involved, excluding extraordinarily rare combinations. Such a flood could occur in the areas considered in this report if a storm equivalent in magnitude to that of the largest storm of record in the general region were to center critically over the drainage area when ground conditions were conducive to a high rate of runoff. The magnitude of such a flood constitutes a reasonable appraisal of the flood-producing potentialities of the streams considered in this report and is considered a reasonable upper limit in determining the size of the flood for which flood-control improvements might be designed.

44. Estimates of the magnitude of the standard project flood for the areas considered in this report are based on calculations of runoff that would result if a storm having characteristics of the August 19, 1954, thunderstorm, which centered over the Queen Creek

drainage area, were to center over the drainage areas considered here. Detailed information on the determination of the standard project flood is given in appendix 1. The peak discharges of uncontrolled standard project floods at pertinent points along the streams under study are given in the following table:

Estimated peak discharges of standard project flood, Phoenix, Ariz., and vicinity (including New River)

Location	Peak discharge*
	Cubic feet per second
Along Cave Creek:	
At Arizona Canal	65,000
At Grand Canal	65,000
Along Skunk Creek, near mouth	55,000
Along New River:	
At Highway 60 bridge	126,000
Along Agua Fria River:	
At Highway 80 bridge	160,000

* Under natural conditions.

45. Maximum probable flood.--The maximum probable flood in terms of peak flow or volume for critical durations is that flood that would result from the most severe combination of meteorological and ground conditions considered possible of attainment in the drainage area generally upstream from an improvement selected for study. Further information on the maximum probable flood, used only as a criterion for spillway design, is included in appendix 1.

EXTENT AND CHARACTER OF OVERFLOW AREA

46. Location and extent.--The total area that would be subject to appreciable damage by floods along Cave Creek, Skunk Creek, the New River, and the Agua Fria River and that would be affected by the improvements considered in this report comprises about 40,800 acres (63.7 square miles).

(a) The Cave Creek overflow area, including the overflow area from the Dreamy Draw-Sunnyslope Washes, is on a broad alluvial fan. Upstream from the Arizona Canal, the streams flow in defined channels of small capacity. Downstream from the Arizona Canal, the urban development that has taken place has obliterated almost all traces of the old channels in this area. Floodflows follow a broad swale through an intensively developed section of Phoenix. The

overflow area has a wide areal extent over which floodflow depths are relatively shallow. The area included in the Cave Creek overflow area amounts to 21,200 acres.

(b) The overflow area along Skunk Creek, the New River, and the Agua Fria River contains about 19,600 acres and is about 25 miles long and about 1 mile wide. The channels for each of these three streams through this overflow area are fairly well defined, resulting in floodflows that are deeper than in the Cave Creek overflow area.

47. Type and value of property in the overflow areas.--The developed areas subject to overflow along Cave Creek, Dreamy Draw, and unnamed washes in the Sunnyslope area are predominantly urban, whereas the overflow areas along Skunk Creek, the New River, and the Agua Fria River are predominantly agricultural. Information on the type and value of improvements in the overflow areas considered is given in the following subparagraphs.

(a) Overflow area along Cave Creek.--This overflow area extends for about 16 miles from just north of Bell Road southward to the Salt River. The overflow area of Cave Creek is approximately 1 mile in width from about Bell Road to the Arizona Canal. Just downstream from the Arizona Canal, owing to the contribution of floodflows from the Dreamy Draw and Sunnyslope areas, the overflow area is nearly 3 miles wide and extends from the Black Canyon Highway on the west to 12th Street on the east. At Van Buren Street - about 8 miles downstream, the overflow area narrows down to a 1-mile width.

(b) The major portion of the development in this area is residential and accounts for about 53 percent of the value and covers about one-third of the area. The residential property includes more than 30,000 homes, ranging in value from $8,000 to $40,000. Several multistory apartment buildings, including a 16-story and a 22-story building, are in the overflow area. Another large item of value is the commercial development, which amounts to about 13 percent of the total. The properties included in this category number more than 1,700 establishments ranging in size from small neighborhood stores to large department stores. Also included in the overflow area are several shopping centers, several multistory office buildings, and about 40 motels catering to commercial travelers and winter vacationers.

(c) The value of almost $88,000,000 for public property includes 36 grade and high schools, 7 hospitals, and 81 churches. Several multistory office buildings in the area would suffer physical flood damages at the street level; in addition, occupants of the upper floors of these buildings would suffer considerable inconvenience during periods of flood. The industrial development

in the area, mostly of the warehouse and light-manufacturing type, includes about 650 separate businesses. A complete complex of utilities, highways, and streets is included in the overflow area. The area has an estimated population of about 95,000 persons. About 38 percent of the entire overflow area is presently undeveloped.

(d) Past growth in the area under consideration, the growth that is now taking place, and forecasts of future growth indicate that future values over the next 100 years will be considerably greater than present values. Analysis was made of (1) population-growth studies of the Phoenix urban area, (2) economic analyses and projections for the city of Phoenix and for Maricopa County, and (3) estimates of land available for expansion and of the availability of water supply. Several private engineering analyses of the Phoenix metropolitan area - made to consider required expansion of utility services, particularly water-supply and sewage-treatment works, and to consider future highway-construction needs - were available for use in this study.

(e) Population projections were made for a 50-year period for the city of Phoenix and for Maricopa County. Because of the large growth expected to occur in the area during the next 50 years and the lack of suitable data to predict growth beyond 50 years, it was conservatively estimated - for purposes of this report - that population and corresponding development would remain constant during the 50- to 100-year period.

(f) These analyses indicated that average future values over the next 100 years, assuming 1963 price levels for the Phoenix metropolitan area, would be about 600 percent greater than present values. The average value of the Cave Creek overflow area over the next 100 years would be about 120 percent greater than the present value. This rate of increase is less than is estimated for the entire Phoenix metropolitan area because of the degree of saturation of present development in the Cave Creek area as compared with the degree of saturation in the entire metropolitan area. The amount and value of agricultural and undeveloped land will decrease to reflect the use of these lands for urban development.

(g) The three sets of oblique aerial photographs (see photos 1-6) indicate the rapid growth and development taking place in and adjacent to the overflow area along Cave Creek.

(h) Overflow areas along Skunk Creek, the New River, and the Agua Fria River.--The overflow areas along Skunk Creek, the New River, and the Agua Fria River amount to 19,600 acres of which 5,600 acres are streambed areas and wasteland not subject to development. About 94 percent of the developable land is developed to agricultural uses. The overflow area extends for about 25 miles

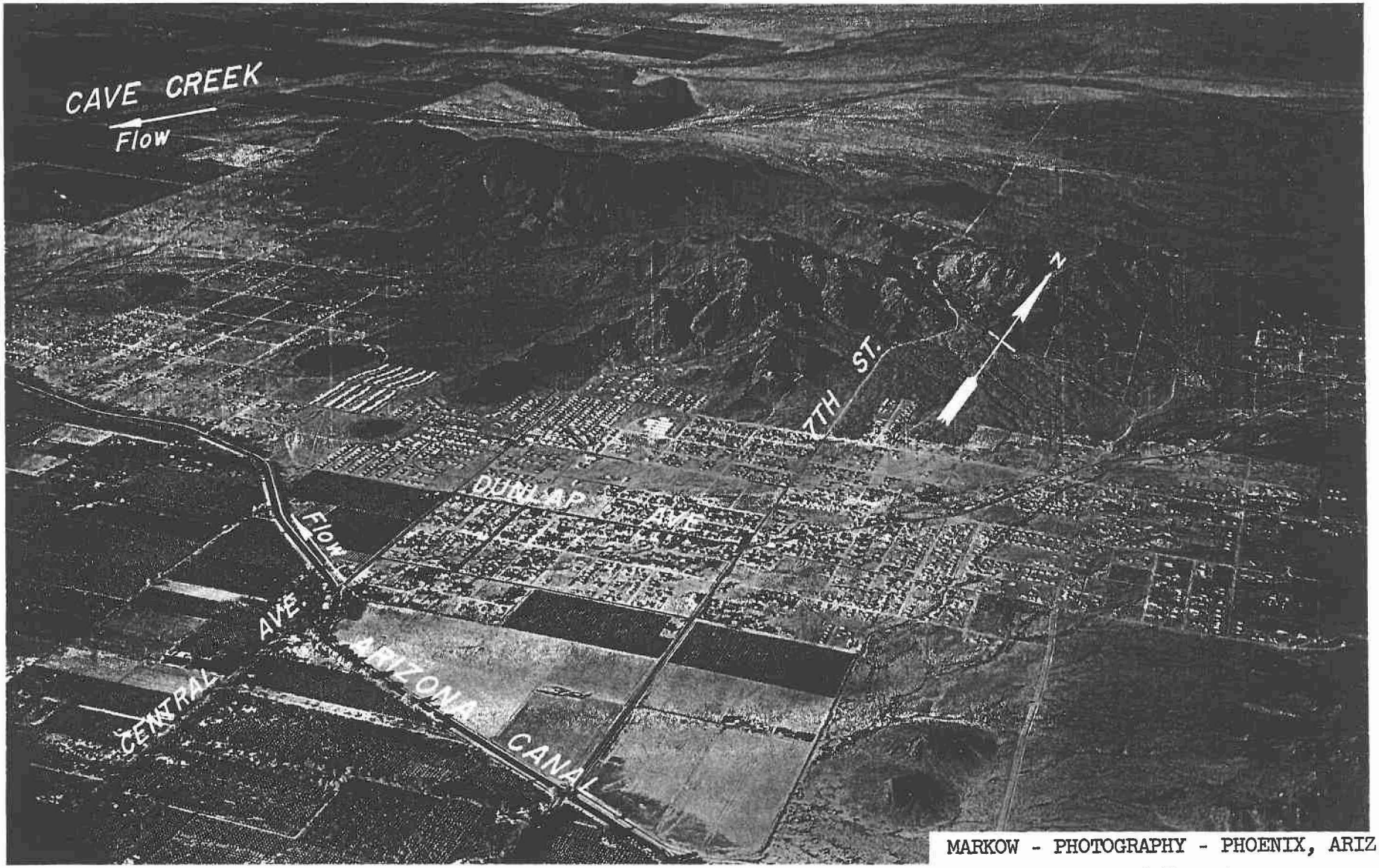


Photo 1 - Sunnyslope, January 1950, a residential and shopping community, now a part of Phoenix.

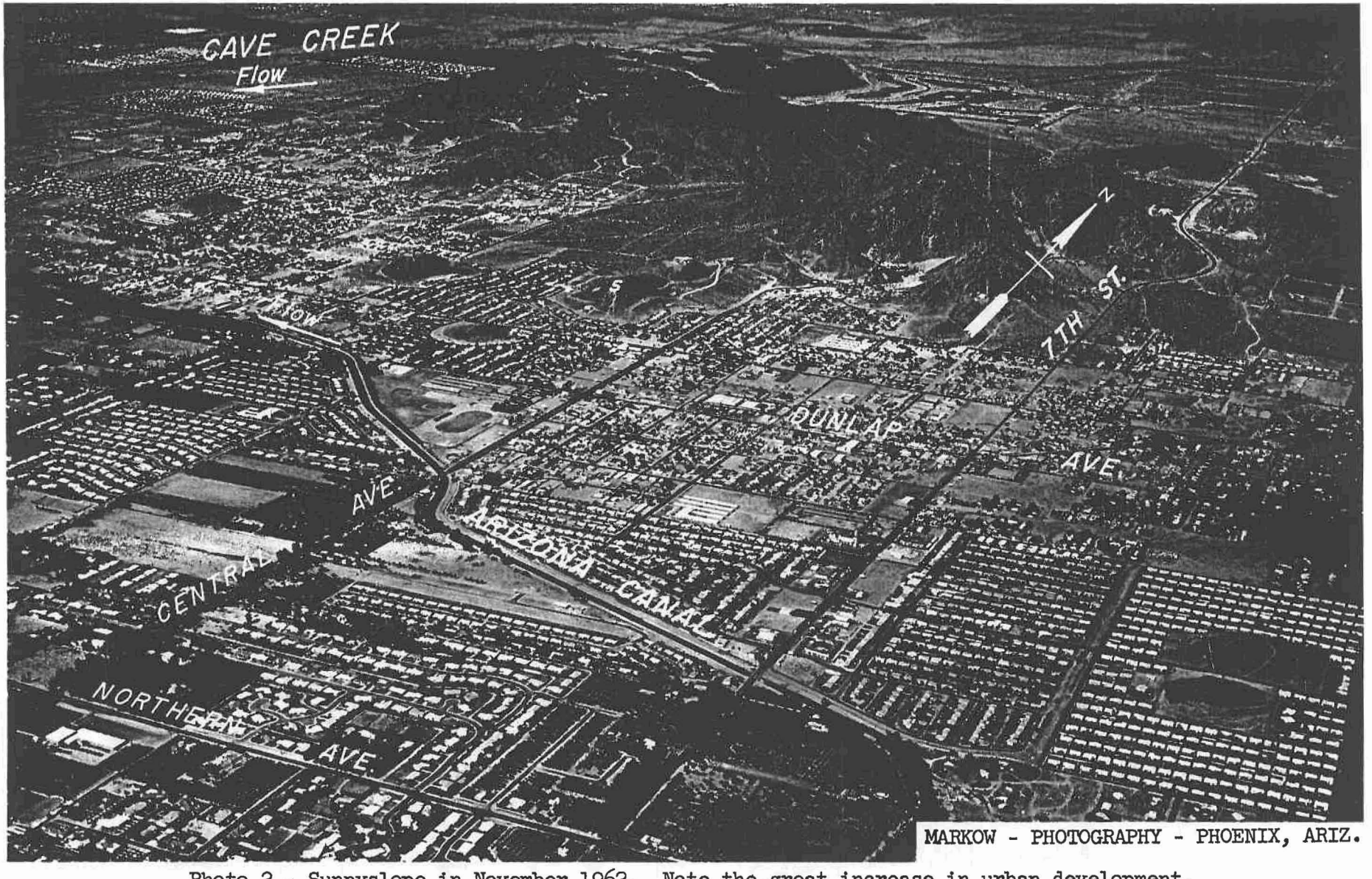
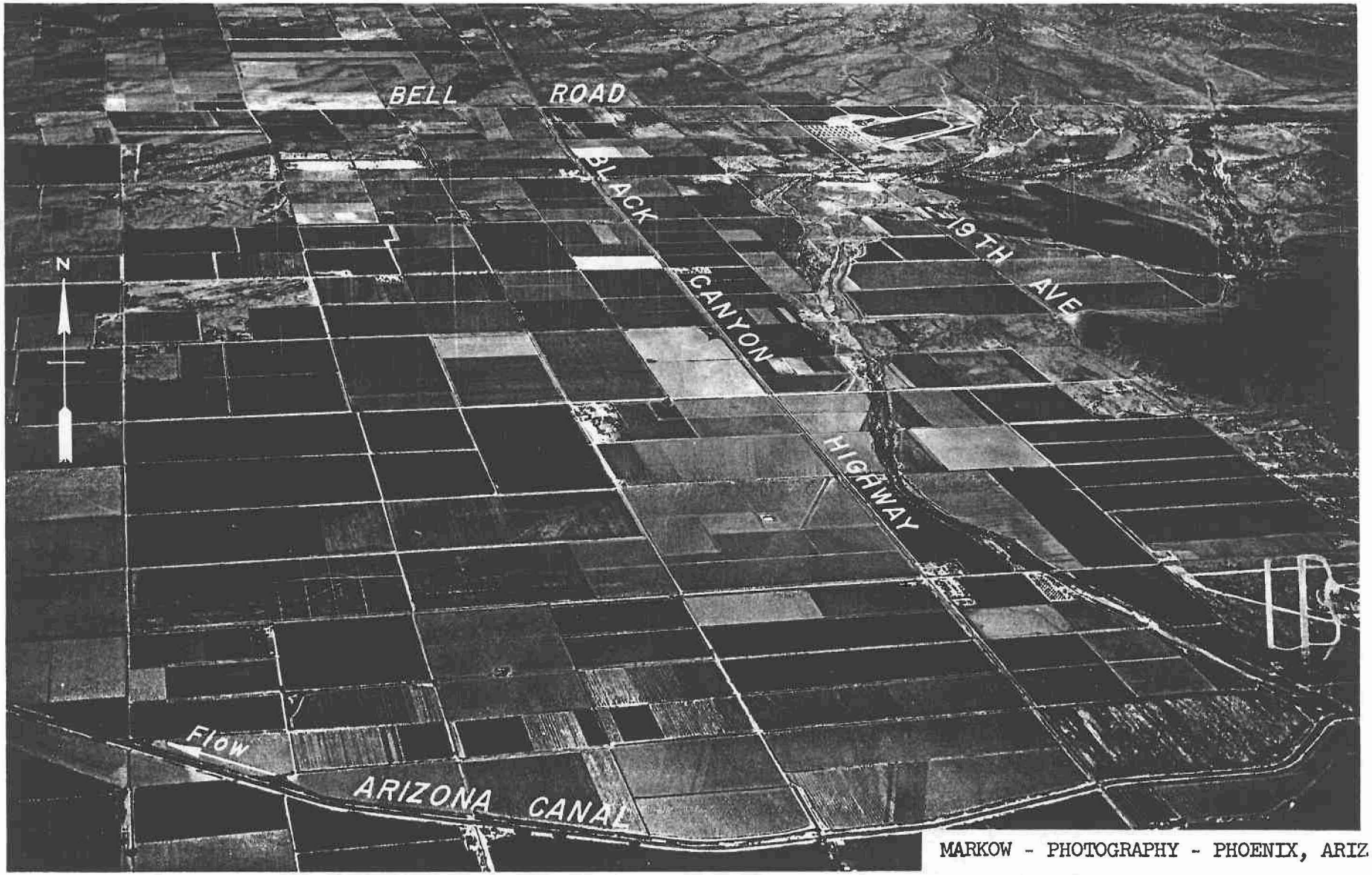


Photo 2 - Sunnyslope in November 1962. Note the great increase in urban development.

Photo 3 - A new industrial and warehouse district in the west part of Phoenix, September 1948.

Photo 4 - Increasing development of the industrial and warehouse district - December 1962.



MARKOW - PHOTOGRAPHY - PHOENIX, ARIZ.

Photo 5 - Irrigated ranchland northwest of Phoenix - March 1957.

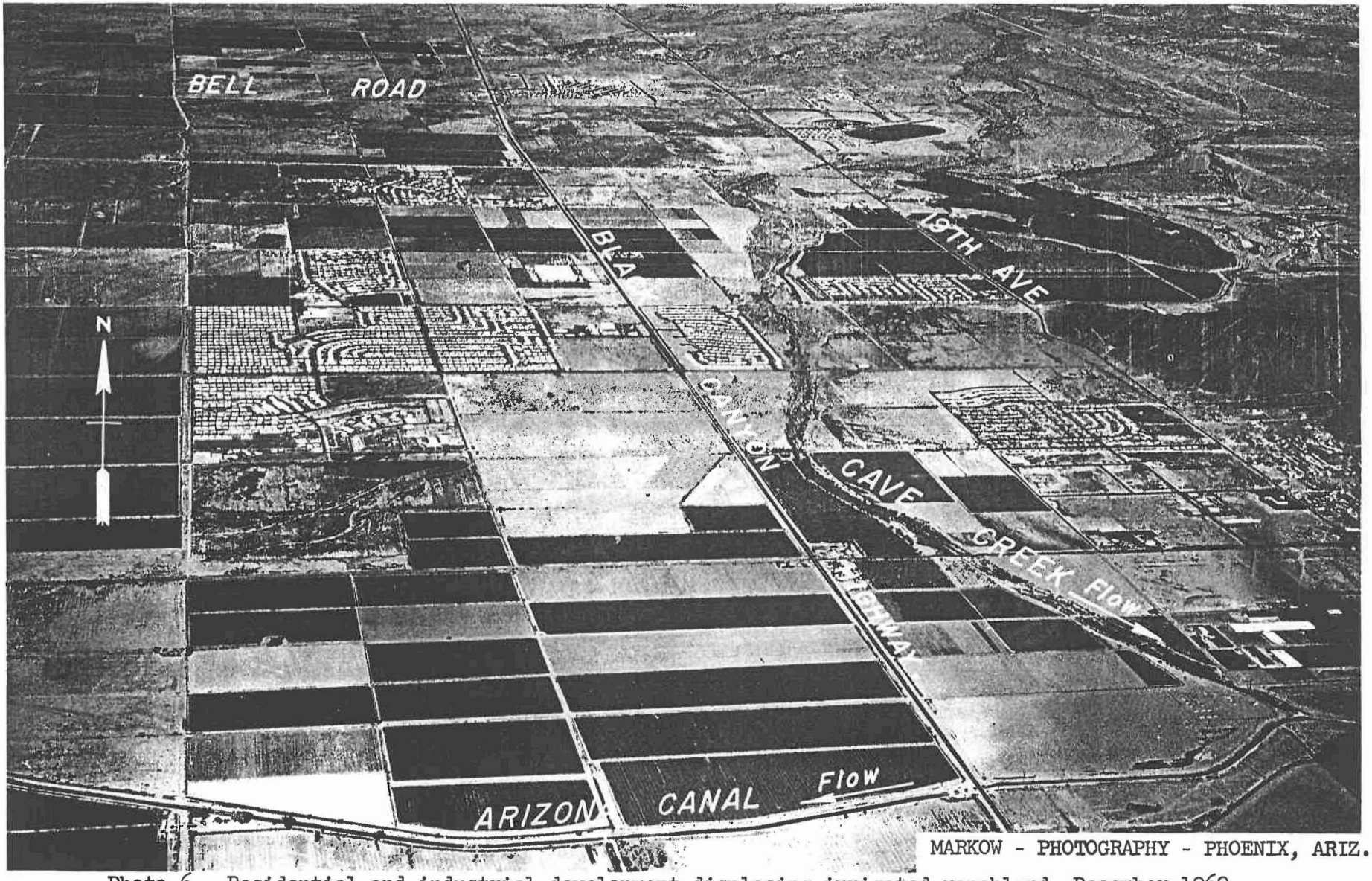


Photo 6 - Residential and industrial development displacing irrigated ranchland, December 1962.

from a point on Skunk Creek, several miles upstream from the New River, to a point near the mouth of the Agua Fria River. The overflow area would range in width from about 1 mile near the New River detention basin to about 2 miles at Peoria. Downstream from the railroad and highway bridge at Peoria, the overflow area would decrease to about 1 mile in width and would remain at about that width through the remaining length of the overflow area.

(i) The agricultural development is the largest single item of value in the overflow area and amounts to 53 percent of the total. Two urban centers, one at the town of Peoria on the New River and the other at Avondale on the Agua Fria River, are subject to damage from a standard project flood. Residential developments include about 750 homes, ranging in value from $2,000 to $9,000. Commercial development in the two towns includes about 50 units. The residential and commercial property - together with utilities, highways, and streets in the area - account for 41 percent of the value of the overflow area, but only occupy about 4 percent of the area. The area has an estimated population of 2,500 persons.

(j) An analysis of the growth patterns within the Phoenix metropolitan area indicates that expansion of the Phoenix urban area to the Skunk Creek-New River-Agua Fria River area will occur within about 5 years. At the present time, areas within the city of Glendale and immediately to the south, in the Maryvale district of Phoenix, are essentially saturated with homes and commercial development. These areas are only 5 to 7 miles from the Skunk Creek-New River-Agua Fria River area. The Youngtown area, a development for senior citizens, is about 2 miles west of the New River on the east bank of the Agua Fria River; and Sun City, another senior-citizen development, is between the New River and the Agua Fria River - adjacent to Youngtown and about 3 miles northwest of Peoria. Because of the expansion of the Phoenix urban area to the Skunk Creek-New River-Agua Fria River area, agricultural development will be displaced by urban-type developments. It is estimated that present urban-type developed areas, which comprise about 4 percent of the land total in the overflow area, will increase to about 20 percent of the land total in 50 years. Under average future conditions, the value of residential and commercial property is expected to comprise about one-half of the value of property in the overflow area, whereas now such property value comprises only about 20 percent of the total value. Average future value in the overflow area of Skunk Creek-New River-Agua Fria River is estimated at about 10 times the present value.

48. To reflect the increase in development over a 100-year period, future values were discounted by the application of present-worth factors. Additional information on the present and estimated average future development in the overflow areas is given in appendix 4. A summary of the values of property in the overflow areas is given in the following table:

Summary of estimated value of property subject to damage by an uncontrolled standard project flood in the overflow areas of Cave Creek, Skunk Creek, New River, and Agua Fria River, Ariz.

Overflow area and type of property	Present (1963) value of property	Average future value of property*
Cave Creek, including Dreamy Draw and unnamed washes in the Sunnyslope area (21,200 acres):**		
Residential	$504,400,000	$1,077,600,000
Commercial	119,100,000	229,400,000
Public	87,900,000	183,200,000
Utilities	77,600,000	153,700,000
Railroad	1,900,000	2,200,000
Industrial	75,700,000	355,000,000
Highways and streets	33,700,000	46,700,000
Agriculture	900,000	300,000
Irrigation	3,300,000	2,900,000
Total	904,500,000	2,051,000,000
Say	905,000,000	2,051,000,000
Skunk Creek, New River, and Agua Fria River (19,600 acres):***		
Residential	4,100,000	114,900,000
Commercial	1,500,000	19,900,000
Public	1,300,000	35,900,000
Utilities	600,000	16,500,000
Railroad	900,000	900,000
Industrial	100,000	37,600,000
Highways and streets	1,900,000	5,200,000
Agriculture (13,200 acres)	13,500,000	12,200,000
Irrigation	1,600,000	1,500,000
Total	25,500,000	244,600,000
Say	26,000,000	245,000,000

* The value of average future development for period 1963-2062 without additional flood control was discounted by using present-worth factors.

** Includes 8,200 acres of undeveloped land under present conditions.

*** Includes 5,600 acres of streambed and wasteland.

FLOOD DAMAGES

49. Damages from past floods.--Monetary estimates of damages from past floods are very scanty; only very general rough estimates are available. The Cave Creek flood of August 1921 - before the construction of Cave Creek Dam - caused damages of "over a million dollars," according to the Arizona Republic. With the tremendous growth of Phoenix, the occurrence of this flood today would cause damages estimated at about $63 million.

50. The Cave Creek flood of August 1943 was destructive; however, no complete monetary estimate of damage was made. The overflow area of Cave Creek affected by this flood was largely agricultural at that time. Because of a lack of interest in flood control at that time, a complete estimate of the damages caused by the 1943 flood was not made. However, newspaper accounts and reports by local agencies indicate the severity of the flood, which resulted from heavy rain from severe thunderstorms over the desert areas just north of Phoenix. Rapid runoff upstream from the Arizona Canal quickly overtaxed the capacity of the canal system. About 16 breaks occurred in the south bank of the canal in the Cave Creek area north of Phoenix. In addition, water overflowed the south bank in that area in about 6 places without breaking the bank. At that time, much of the area downstream from the Arizona Canal was in citrus groves or other agricultural pursuits that were not seriously damaged by the floodwaters. The reports available indicate that a hundred or more homes and business establishments were flooded by water that ranged in depth from a few inches to 2 feet. Floodwaters in several major streets made travel impossible for several hours. If the 1943 flood were to occur today under present intensive development, damages of about $20 million would result. A report made by the Soil Conservation Service about the August 1943 flood along the New River (peak discharge of 38,000 cubic feet per second) indicated that flood damages totaled $47,500 (1943 prices and development). The report states, however, that information on which the estimate was based was very limited. A similar flood occurring today along the New River would result in damages of about $590,000. This large increase is due to (1) the increase in urban-type development along the banks of the New River and the Agua Fria River at Peoria and Avondale, respectively; (2) the increase in the area farmed along the rivers; (3) the price-level increase from 1943 to 1963; and (4) consideration of all potential damages.

51. The population of the Phoenix metropolitan area has increased approximately 310 percent from 1950 to 1960 and has increased by nearly 15 percent in the past 3 years, mostly as a result of migration into the State. Most of those living in the overflow areas today have never experienced floods of destructive magnitude in or near Phoenix. The largest damaging flood of recent years in the general area occurred in September 1962 along

Santa Rosa Wash, about 50 miles south of Phoenix. That flood resulted in damages of about $10 million, mostly to agricultural properties. Because Phoenix and Santa Rosa Wash are in the same region of meteorological homogeneity, it is possible and probable that a storm such as the 1962 Santa Rosa storm could occur in the Phoenix area. If that storm had centered over the Cave Creek drainage area, the resultant discharge of Cave Creek at the Grand Canal would have been about 26,000 cubic feet per second, causing damages under present conditions of about $57 million.

52. In August 1963, a cloudburst storm over the Glendale-Maryvale area at the western outskirts of the Phoenix urban area resulted in large damages to residential, commercial, and other urban and agricultural properties. Although final compilation of the damages has not been completed, preliminary tabulations indicate that they will exceed $1 million. The damaged area is within the overflow area of tributaries of the Salt, the New, and the Agua Fria Rivers, just west of the Cave Creek drainage area.

53. Damages from future floods.--Hydraulic and economic studies were made to determine the effect of floods of various magnitudes on present and future development. The estimate of damage from a single flood included consideration of the probable extent of the overflow area, the type and value of property subject to damage, and the extent of damage that would occur to each type of property from floodwaters of computed depth and velocity. The selected flood magnitudes range from a discharge that would cause a small amount of damage to the discharge of the standard project flood. The estimates of damage include physical damages, emergency costs, and business and financial losses that would be caused in the overflow area by floods of various magnitudes.

54. The following tables give (a) pertinent information on damages that under present conditions (1963) would occur to various types of property as a result of a standard project flood and (b) a summary of the estimated damages from future floods of various magnitudes in the overflow areas.

Estimated damages resulting from an uncontrolled standard project flood along Cave Creek,* Skunk Creek, New River, and Agua Fria River, Ariz.

Overflow area and type of property	Present (1963) value	Damages based on present (1963) conditions		
		Physical damages	Emergency costs and business losses	Total
Cave Creek:*				
Residential	$504,400,000	$67,970,000	$6,800,000	$74,770,000
Commercial	119,100,000	12,090,000	3,630,000	15,720,000
Public	87,900,000	4,450,000	670,000	5,120,000
Utilities	77,600,000	2,630,000	390,000	3,020,000
Railroad	1,900,000	120,000	20,000	140,000
Industrial	75,700,000	5,850,000	1,760,000	7,610,000
Highways and streets	33,700,000	1,930,000	1,330,000	3,260,000
Agriculture	900,000	230,000	20,000	250,000
Irrigation	3,300,000	340,000	20,000	360,000
Total	904,500,000	95,610,000	14,640,000	110,250,000
Say	905,000,000	95,000,000	15,000,000	110,000,000
Skunk Creek, New River, and Agua Fria River:				
Residential	4,100,000	460,000	90,000	550,000
Commercial	1,500,000	300,000	60,000	360,000
Public	1,300,000	140,000	20,000	160,000
Utilities	600,000	30,000	3,000	33,000
Railroad	900,000	230,000	160,000	390,000
Industrial	100,000	20,000	4,000	24,000
Highways and streets	1,900,000	500,000	100,000	600,000
Agriculture	13,500,000	1,190,000	223,000	1,413,000
Irrigation	1,600,000	240,000	60,000	300,000
Total	25,500,000	3,110,000	720,000	3,830,000
Say	26,000,000	3,100,000	700,000	3,800,000

* Includes Dreamy Draw and unnamed washes in Sunnyslope area.

Summary of estimated damages from future floods of various magnitudes, Phoenix, Ariz., and vicinity (including New River)

Overflow area	Flood magnitude	Damages based on present (1963) development and price levels			Total damage based on present worth of average future development*
		Physical damages	Emergency costs and business losses	Total	
Cave Creek (including Dreamy Draw and unnamed washes in the Sunnyslope area)	cubic feet per second				
	**65,000	$95,000,000	$15,000,000	$110,000,000	$249,500,000
Do	30,000	54,000,000	10,000,000	64,000,000	143,000,000
Do	9,000	15,000,000	4,500,000	19,500,000	40,000,000
Do	600	0	0	0	0
Skunk Creek, New River, and Agua Fria River	**126,000	3,100,000	700,000	3,800,000	46,000,000
Do	22,000	590,000	110,000	700,000	7,000,000
Do	12,000	250,000	50,000	300,000	2,700,000
Do	1,000	0	0	0	0

* For period 1963-2062 without additional flood control (based on 1963 price levels).
** Standard project flood.

Note.--Flood magnitudes for Cave Creek and New River are measured at the Arizona Canal and Highway 60 bridge, respectively.

55. Average annual damages.--Curves were drawn showing the relationship between peak discharges and resultant damages under conditions of average future development for each overflow area considered in detail in this study. Damage-frequency curves (see pls. 2 and 3 of app. 4) were prepared by combining each discharge-damage curve with the corresponding discharge-frequency curve described under a preceding heading "Flood Frequencies."

56. The areas under the damage-frequency curves represent the estimated average annual flood damage for that area. The average annual flood damages, based on present and average future conditions of development, are shown in the following table:

Estimated average annual damages in overflow areas of Phoenix, Ariz., and vicinity (including New River)

Overflow area	Average annual damages under present (1963) development	Average annual damages under average future conditions*
Cave Creek (including Dreamy Draw and unnamed washes in Sunnyslope area)	$3,410,000	$7,420,000
Skunk Creek, New River, and Agua Fria River	130,000	1,250,000
Total	3,540,000	8,670,000

*Based on (a) the value of average future development (1963-2062) after discounting to present worth and (b) 1963 price levels.

57. Intangible damages.--In addition to the tangible damages evaluated in this report, serious damages not susceptible of monetary evaluation would result from future floods in the overflow areas considered here. See subsequent heading entitled "Estimate of Benefits" for a discussion of these damages.

EXISTING CORPS OF ENGINEERS FLOOD-CONTROL IMPROVEMENTS

58. No existing flood-control project in the drainage areas under detailed consideration in this report is under the jurisdiction of the U.S. Army Corps of Engineers, and the improvements being considered for construction would not be affected by any other Corps of Engineers improvement except McMicken Dam, from which flows are conveyed to the Agua Fria River.

59. Discharges from the considered improvements, however, would empty into the Gila River channel to be cleared under the existing Corps of Engineers project for the Gila and Salt Rivers levee and channel improvement. That project, which was authorized by the Flood Control Act of July 14, 1960, would include (a) levees along the Salt River in the vicinity of Phoenix and Tempe, Ariz., (b) a cleared floodway along the Salt and Gila Rivers between Granite Reef and Gillespie Dams, and (c) low-flow or pilot channels along parts of the cleared floodway. (See H. Doc. 279, 86th Cong., 2d sess.).

60. In addition, since authorization of the Gila and Salt Rivers levee and channel improvement, studies under way by the Bureau of Reclamation indicate the economic justification of a multiple-purpose reservoir on the Salt River at the Maxwell (formerly called McDowell) site. Present plans for this reservoir provide sufficient flood-control storage to control a standard project flood (peak discharge 290,000 c.f.s.) to an outflow of 50,000 cubic feet per second. Because of the control that would be effected by Maxwell Reservoir, the levees along the Salt River in the vicinity of Phoenix and Tempe, Ariz., are no longer required. However, the comprehensive plan for the Phoenix metropolitan area provides for channel improvements along the Salt River from Granite Reef Dam to the mouth of the Salt River mostly to permit higher utilization of lands in the Salt River channel in the Phoenix urban area.

IMPROVEMENTS BY OTHER FEDERAL AND NON-FEDERAL AGENCIES

61. Cave Creek flood-control dam, located about 6 miles upstream from Bell Road, was completed in March 1923 at a cost of $550,000. The dam, constructed to control Cave Creek floods, is a concrete multiple-arch structure. It was financed by a cooperative effort of State, county, city, and private interests. Under the assumption that the reservoir would be empty and the three outlets would be operating, it is estimated that the dam would at present control all floods up to a peak inflow of about 13,000 cubic feet per second. A flood with that peak inflow, which would have a frequency of occurrence of about once in 50 years, would be reduced to a maximum discharge of 1,250 cubic feet per second. If a standard project flood were to occur today, the dam under the same assumption would reduce a flow of 83,000 cubic feet per second at the Grand Canal to 47,000 cubic feet per second. When constructed, the capacity of the reservoir was 14,000 acre-feet. However, in 1948 after a 25-year operation period, a survey of the reservoir indicated that the capacity was only 11,000 acre-feet - a loss of 3,000 acre-feet because of sedimentation, with a resultant reduction to about 78 percent of original capacity. At the same rate of sedimentation, the entire reservoir would be completely depleted within a period of about 75 years from this date (1963).

62. Lake Pleasant Reservoir was constructed in 1927 on the Agua Fria River about 25 miles upstream from the mouth of the New River. The 164,000-acre-foot reservoir, constructed by the Maricopa County Municipal Water Conservation District No. 1, is used for water conservation but provides incidental flood control. The reservoir has been filled only once since its construction in April 1941, and at that time an estimated 500 acre-feet of water passed over the spillway.

63. The irrigation canals of the Salt River project are operated to provide limited flood control. If floodflow is anticipated, the irrigation water is released into wasteways and the canal emptied. The canals have a varying capacity in different reaches as follows:

Arizona Canal:
  Near Dreamy Draw.....800 cubic feet per second
  Near Cave Creek.....600 cubic feet per second
Grand Canal near
  Central Ave.....about 600 cubic feet per second

IMPROVEMENTS DESIRED

64. Public hearing.--A public hearing was held at Phoenix, Ariz., on December 9, 1959, by the U.S. Army Engineer District, Los Angeles, with the district engineer presiding. It was attended by 178 persons, including interested private citizens and representatives of various agencies of the Federal Government, the State of Arizona, Maricopa County, and political subdivisions of the county. The Maricopa County Flood Control District presented an outline of a comprehensive plan of improvement for the Phoenix metropolitan area, as described in the following paragraphs.

65. Improvements desired by local interests.--Local interests proposed, in very general terms, a comprehensive plan of improvement to protect the entire Phoenix metropolitan area, as follows:

(a) Channelization of the Salt River from east of Mesa to a point west of Phoenix.

(b) Channels to divert to the Salt River those flows originating in the mountain areas east of Mesa and south of the Salt River that affect agricultural areas and the communities of Higley, Gilbert, and Apache Junction.

(c) Channels to divert flows from the developed areas east of Indian Bend Wash to the Salt River.

(d) Channelization of Indian Bend Wash.

(e) A system of channels to divert Cave Creek flows and flows originating in Sunnyslope and the Phoenix Mountains westward from the urban area of Phoenix to Skunk Creek and the New River.

(f) Channelization of Skunk Creek and the New and the Agua Fria Rivers from the mouths of the diversion channels to the Gila River.

(g) A channel to divert flows originating in the Salt River Mountains from the developed areas of south Phoenix.

(h) A diversion channel just north of the Arizona Canal to divert flow eastward from about 36th Street and westward from about 56th Street to an outlet channel at about 48th Street that would empty into the Salt River. These works would convey floodflows from the mountainous area north of the Arizona Canal between 36th Street and 56th Street to the Salt River.

(i) Local interests also requested that consideration be given to construction of a multiple-purpose dam on the New River at a point about 3 miles north of the settlement of New River, in conjunction with a channel to divert the New River flows to the Agua Fria River upstream from Lake Pleasant Reservoir.

66. After the public hearing, local interests requested the Soil Conservation Service, U.S. Department of Agriculture, to consider the flood problems of the communities of Higley, Gilbert, and Apache Junction and of the adjoining agricultural areas (item (b) of the preceding paragraph titled "Improvements Desired by Local Interests"). The results of their studies are contained in the recently completed watershed-work plan.

67. Reasons advanced in justification of improvements desired.--Representatives of local interests stressed the need for flood control along the previously mentioned streams to (a) prevent inundation of highly developed residential and commercial areas, (b) prevent damage to agricultural property, (c) prevent interruption of the delivery of irrigation water in the many canals used for that purpose, and (d) prevent interruption of highway and street traffic. They pointed out that past floods on tributaries of the Salt and Gila Rivers in the Phoenix metropolitan area rarely caused large damages, mainly because of the predominantly agricultural developments in the overflow areas. However, with the population explosion in the Phoenix metropolitan area, the damage potential has increased tremendously.

FLOOD PROBLEMS AND RELATED PROBLEMS

68. A serious flood problem exists along Dreamy Draw, Cave Creek, and Skunk Creek and along the New and the Agua Fria Rivers, the major streams under detailed consideration in this report. Until recently,

floods along Dreamy Draw and Cave Creek rarely caused large damages, mainly because of the predominantly agricultural developments in the overflow area. However, with the population explosion in the Phoenix metropolitan area, particularly since 1950, the flood-damage potential has increased tremendously. The flood channels of Dreamy Draw and Cave Creek disappear at the Arizona Canal and not even a trace of a stream is evident downstream. The area downstream from the canal is now intensively developed with urban-type property - predominantly residential, commercial, and industrial improvements. Floods along Skunk Creek, the New River, and the Agua Fria River cause damage to mainly agricultural-type property, except at the communities of Peoria and Avondale.

69. Damage to property in the overflow areas is caused principally by inundation and debris deposition. The floodflows result primarily from local thunderstorm rainfall of high intensity and short duration. Along the New River and the Agua Fria River, severe bank and surface erosion occurs. Inundation damage will also cause severe disruption of activities, both inside and outside the flooded area. Because of the continued growth in the overflow area, damages will be greater under future conditions than under present conditions.

70. Water-conservation problems or other problems related to flood problems are not of sufficient magnitude to warrant detailed investigation in connection with this flood-control survey.

PLANS OF IMPROVEMENT CONSIDERED

71. General.--Because of high evaporation rates and relatively low average-annual rainfall, no detailed studies were made of a Federal multiple-purpose project providing for water conservation, hydroelectric power, fish-and-wildlife development, or recreational development in addition to flood control.

72. However, because of the exploding population in the Phoenix area, the possibility of recreational development at detention-basin sites was recognized even though no permanent pools would be provided. Available information on real estate costs indicates that cost to local interests for fee acquisition rather than flowage-easement acquisition in the detention-basin areas required for recreational development would be relatively minor.

73. Comprehensive plan.--A comprehensive five-phase flood-control plan for the Phoenix metropolitan area was developed by the Corps of Engineers in cooperation with the Flood Control District of Maricopa County to serve as a framework for all flood-control work in the area, whether justified at this time or not. Pertinent information on those five phases is given in the following subparagraphs.

(a) Phase A provides for a channel improvement along Indian Bend Wash from the Arizona Canal to the Salt River, as recommended in the interim report on Indian Bend Wash, Ariz. That report, which was completed by the U.S. Army Engineer District, Los Angeles, on April 15, 1962, is being processed for submission to Congress.

(b) Phase B provides for a system of detention basins, diversion channels, and channel improvements as described in the recommended plan given in this report.

(c) Phase C provides for (1) channels in the Glendale-Maryvale area and (2) a detention basin, diversion channel, and channel improvement in the south Phoenix area.

(d) Phase D provides for (1) flood-control storage in Maxwell Reservoir under consideration by the Bureau of Reclamation and (2) a channel improvement along the Salt River from the Granite Reef diversion dam to the mouth of the Salt River at its confluence with the Gila River.

(e) Phase E provides for a channel improvement along Indian Bend Wash upstream from the Arizona Canal.

74. Plans proposed by local interests.--The plans proposed at the public hearing by local interests for flood control in the Phoenix metropolitan area are listed in a preceding paragraph, "Improvements Desired by Local Interests." Since the public hearing, the Corps of Engineers has worked closely with the Flood Control District of Maricopa County to refine the proposals and to develop the comprehensive plan presented in the preceding paragraph. The results of studies and investigations for that plan and proposals for future study are summarized in following paragraphs.

(a) Study for channelization of the Salt River through the Phoenix area will be included in phase D, which is mentioned in the preceding paragraph.

(b) The flood problems of the area east of Mesa, in the communities of Higley, Gilbert, and Apache Junction, and of the adjoining agricultural areas, have been studied by the Soil Conservation Service, U.S. Department of Agriculture. The results of their studies are contained in a recently completed watershed work plan.

(c) Study of the flood problems of the areas east of Indian Bend Wash is interconnected with improvements for implementation of the Bureau of Reclamation's proposed Central Arizona Project. The best solution to the flood problem appears to require the construction of a diversion channel along the base of the southwest slope of the McDowell Mountains. Such a diversion channel would traverse the Salt River Indian Reservation just before it reaches a discharge

point in the Salt River, about 9 miles east of Scottsdale, Ariz. The Granite Reef aqueduct of the Central Arizona Project would traverse the same area as the proposed diversion channel. In addition, flood-control works would be required for the protection of the aqueduct. Members of the tribal council of the Salt River Indian Reservation and representatives of the Bureau of Indian Affairs desire that decisions regarding location or design of a diversion channel through reservation land should be held in abeyance until a firm location of the aqueduct is established and the nature of the flood-protection works for it are determined. Further study of the flood problems in this area would be made in cooperation with the Bureau of Reclamation after the Bureau's plans are firmed up.

(d) Study of channelization of Indian Bend Wash from the Arizona Canal to the Salt River has been completed by the U.S. Army Engineer District, Los Angeles, and the recommendations resulting therefrom are included in an interim report dated April 15, 1962. That interim report also concluded that a channel improvement along Indian Bend Wash upstream from the Arizona Canal is not justified at this time. However, such a channel improvement should be part of any comprehensive plan of the area so that it can be built when justified.

(e) Study of the flood problems of Cave Creek and those caused by flows from the Sunnyslope area and from the Phoenix Mountains resulted in the plan of improvement recommended in this report.

(f) Local interests' desire for channelization of Skunk Creek, the New River, and the Agua Fria River is being fulfilled by inclusion of these improvements as part of the recommended plan contained in this report.

(g) Studies for a channel to divert flows originating in the Salt River Mountains from the developed areas of south Phoenix will be considered under phase D of the comprehensive plan. Phase D will also include a study of the flood problems of the Glendale-Maryvale area. The magnitude of the problems in that area were not realized at the time of the public hearing. However, urban development has expanded into the area within the past 4 years, and a recent storm - in August 1963 - has demonstrated the need for a solution to the flood problems in that area.

(h) Studies of a diversion channel just north of the Arizona Canal, in the area between 36th and 56th Streets, and an outlet channel to the Salt River, at about 48th Street, resulted in the conclusion that such an improvement could not be economically justified. Contributing to the low benefit-cost ratio was the very high cost of improvement required.

(i) Consideration was given to a multiple-purpose dam providing for water-conservation and flood-control storage on the upper New River as requested by local interests. However, such a dam was not considered in detail because of the minor flood-control benefit that would accrue as compared with the flood-control benefit that would accrue from a detention basin at a site farther downstream.

75. Recommended plan.--The recommended plan comprises (a) four dams, one each on Cave Creek, Skunk Creek, the New River, and Dreamy Draw; (b) the Union Hills and the Arizona Canal diversion channels; and (c) the Cave Creek, the Dreamy Draw, the Skunk Creek, the New River, and the Agua Fria River channel improvements. Efforts were directed to control as much of the floodflow as possible in the drainage area involved; to divert residual flows in Deer Valley and Cave Creek to Skunk Creek; and to improve Skunk Creek, the New River, and the Agua Fria River to carry these residual flows to an adequate point of disposal.

76. Pertinent information on each of the units of improvements under the recommended plan is given in the following subparagraphs.

(a) Cave Buttes detention basin.--The Cave Buttes detention basin (with two dikes) would be constructed about 2 miles downstream (south) from the existing Cave Creek Dam. The main embankment would be a compacted-earthfill structure with a maximum height of about 120 feet above streambed. The crest of the dam (elevation 1,621 feet) would be about 2,100 feet long. The unlined spillway, excavated in rock, located about 800 feet northwest of the west (right) abutment of the main embankment, would have a concrete sill with a length of 400 feet at elevation 1,596.5 feet. The spillway would be designed to pass a spillway design flood having a peak discharge of 160,000 cubic feet per second with 5.5 feet of freeboard. The outlet would be a 12-foot-diameter ungated concrete conduit, located under the main embankment near the right abutment. The capacity of the outlet works would be about 5,400 cubic feet per second with the water surface at the spillway crest. Two earthfill dikes would be required. The west dike would have a crest length of 3,500 feet and a maximum height of 90 feet. The east dike would have a crest length of 8,600 feet and a maximum height of 75 feet. The detention basin would have a capacity of 28,800 acre-feet at the spillway crest, of which 2,500 acre-feet would be for

the accumulation of sediment over a 100-year period. The detention basin would reduce a standard project flood with a peak inflow of 79,000 cubic feet per second to an outflow of 5,400 cubic feet per second.

(b) Cave Creek channel.--The Cave Creek channel would be a trapezoidal concrete-lined channel about 3.6 miles long. It would extend from the outlet of the proposed Cave Buttes Dam to the proposed Union Hills diversion channel. The channel would have a bottom width of 10 feet and side slopes of 1 vertical on 2-1/4 horizontal. The depth of the channel would be about 11 feet and the entire channel would be excavated below natural ground. The channel would accommodate a design discharge of 6,000 cubic feet per second. No bridges or utility relocations are expected.

(c) Union Hills diversion channel.--The Union Hills diversion channel would be a trapezoidal concrete-lined channel about 9-3/4 miles long extending from the divide between Cave Creek and Indian Bend Wash drainage areas, near 40th Street, to Skunk Creek. It would have a bottom width ranging from 15 to 60 feet and side slopes of 1 vertical on 2-1/4 horizontal. The design discharge of the channel would range from 2,000 cubic feet per second at the upstream end to 13,400 cubic feet per secomd at the downstream cutlet into Skunk Creek. The depth of the channel would range from 10 to 18 feet, and the channel would be excavated entirely below natural ground. Seven bridges - one each at 32nd Street, Union Hills Drive, Cave Creek Road, 7th Street, 19th Avenue, Black Canyon Highway, and 35th Avenue - would be required. About 1,800 feet of Union Hills Drive would be relocated.

(d) Dreamy Draw detention basin.--The Dreamy Draw detention basin would be constructed in Dreamy Draw just south of Shea Boulevard and 1 mile east of 16th Street. The main embankment would be a compacted-earthfill structure with a maximum height of about 50 feet above streambed. The crest of the dam (elevation 1,420 feet) would have a length of 480 feet. The unlined spillway would be excavated in rock about 400 feet southeast of the left abutment of the main embankment. It would have a concrete sill with a length of 275 feet at elevation 1,410.0 feet. The spillway would be designed to pass a spillway-design flood having a peak discharge of 9,700 cubic feet per second with 5 feet of freeboard. The outlet would consist of a 36-inch-diameter ungated reinforced-concrete conduit located in the main embankment. The capacity of the outlet would be 100 cubic feet per second with the water

surface at the spillway crest. Two earthfill dikes just upstream from the main embankment and along the right bank of Dreamy Draw would be required. One dike would be about 950 feet long and have a maximum height of 22 feet; the other would have a length of 850 feet and a maximum height of about 12 feet. The detention basin would have a capacity of 450 acre-feet at the spillway crest, of which 150 acre-feet would be allocated for the accumulation of sediment over a 100-year period. The detention basin would reduce a standard project flood with a peak inflow of 2,180 cubic feet per second to an outflow of 100 cubic feet per second.

(e) Dreamy Draw channel.--The Dreamy Draw channel would be a rectangular concrete channel with a 10-foot base width, extending from the Dreamy Draw detention-basin outlet to the Arizona Canal diversion channel - a length of about 3-1/2 miles. The design capacity would range from 100 cubic feet per second at the upstream end to 1,500 cubic feet per second at the downstream end. The depth of the channel, which would be excavated entirely below the natural ground, would range from 7 to 9 feet. Six street-crossing bridges would be required - one each at Shea Boulevard, 16th Street, Winter Drive, 14th Street, Belmont Avenue, and 12th Street.

(f) Arizona Canal diversion channel.--The Arizona Canal diversion channel would be just upstream from the Arizona Canal and would be nearly parallel to that canal. At the upstream end, a rectangular concrete channel, 2 miles in length, extending from a point just west of 12th Street to Central Avenue, would have a bottom width ranging from 10 to 50 feet and a depth ranging from 8 to 18 feet. The downstream end, 10 miles in length and extending from Central Avenue to Skunk Creek, would be a trapezoidal earth section with a bottom width ranging from 20 to 220 feet and a depth ranging from 8 to 20 feet. The side slopes of 1 vertical on 2-1/4 horizontal would be revetted with stone underlain by a gravel filter. The design capacity of the channel would range from 1,500 to 18,500 cubic feet per second.

(g) A reinforced-concrete transition channel and a side-channel spillway structure would be constructed at the Skunk Creek channel to assure proper confluence of the two flows. Nine bridges would be required - one each at 7th Street, Central Avenue, 7th Avenue, 19th Avenue, Black Canyon Highway, 43rd Avenue, 51st Avenue, 59th Avenue, and Northern Avenue.

(h) Adobe detention basin.--The Adobe detention basin would be constructed on an unnamed tributary of Skunk Creek, about 7 miles north of Bell Road and about 1 mile west of the Black Canyon Highway. The embankment would be a compacted-earthfill

structure with a maximum height of about 76 feet above streambed. The crest of the dam (elevation 1,561 feet) would have a length of 3,850 feet. An unlined spillway, excavated in rock 700 feet north of the left abutment of the embankment, would have a concrete sill with a length of 250 feet at elevation 1,542 feet. The spillway would be designed to pass a spillway-design flood having a peak discharge of 105,000 cubic feet per second with 5 feet of freeboard. The outlet would be an 8-foot-diameter ungated reinforced-concrete conduit located through the embankment near the right abutment. The capacity of the outlet would be 2,000 cubic feet per second with the water surface at the spillway crest. The detention basin would have a capacity of 19,400 acre-feet, of which 5,500 acre-feet would be allocated for the accumulation of sediment over a 100-year period. The detention basin would reduce a standard project flood with a peak inflow of 50,000 cubic feet per second to an outflow of 2,000 cubic feet per second.

(i) A diversion channel about 2-1/2 miles long would be excavated in earth to divert a standard project flood on Skunk Creek to the Adobe detention-basin area. The channel would be located with its downstream end about 5,000 feet north of the left abutment of the main embankment. The downstream end of the diversion channel would be just above the water surface of the standard project flood in the detention basin. A revetted earth levee set back 100 feet from the channel would prevent the standard project flood from bypassing the detention basin under adverse channel conditions. Construction of the diversion channel would require construction of a bridge for the Black Canyon Highway.

(j) Skunk Creek channel.--The Skunk Creek concrete-lined trapezoidal channel would be constructed along Skunk Creek from a point just upstream from the outlet of the Union Hills diversion channel downstream to a confluence with the New River, a distance of about 6-1/2 miles. The design capacity of the channel would range from 24,400 to 41,400 cubic feet per second. The channel would have base widths ranging from 15 to 40 feet and depths ranging from 10 to 23 feet. The side slopes would be 1 vertical on 2-1/4 horizontal. Three bridges would be required - one each at 59th Avenue, Bell Road, and 83rd Avenue; and about 2,000 feet of Union Hills Drive would be relocated.

(k) The inlet for the channel would consist of a concrete-lined transition. Two wing levees - each about 1,500 feet long, with stone facing, and extending to high ground on the left and right banks - would train the flow to the transition. Downstream from the Arizona Canal confluence, the channel - with a base width of 40 feet - would end in a stone-lined transition that would act as an energy dissipator to reduce velocity of flows entering the New River channel. The maximum depth in the concrete channel of 21 feet and the maximum velocity of 31 feet per second would be reduced by the stone-lined outlet transition to 7 feet and to 15 feet per second, respectively.

(l) New River detention basin.--The New River detention basin would be constructed on the New River about 8 miles upstream from the confluence with Skunk Creek. The main embankment would be a compacted-earthfill structure with a maximum height of about 80 feet above streambed. The crest of the embankment (elevation 1,474 feet) would be 2,700 feet long. An unlined spillway, excavated in rock 1,600 feet east of the left abutment of the main embankment, would have a concrete sill with a length of 800 feet at elevation 1,458 feet. The spillway would be designed to pass a spillway-design flood having a peak discharge of 128,000 cubic feet per second with 5-1/2 feet of freeboard. The outlet would be a 6-foot-diameter ungated reinforced-concrete conduit located under the main embankment near the right abutment. The capacity of the outlet works would be 1,000 cubic feet per second with the water surface at the spillway crest. An earthfill dike, about 7,000 feet northwest of the right abutment of the main embankment, would be required along the west edge of the detention-basin area to confine the design flood. The dike would have a crest length of 4,900 feet and a maximum height of 22 feet. The detention basin would have a capacity of 39,500 acre-feet, of which 10,000 acre-feet would be allocated for the accumulation of sediment over a 100-year period. The detention basin would reduce a standard project flood with a peak inflow of 60,000 cubic feet per second to an outflow of 1,000 cubic feet per second.

(m) New River channel improvement.--The improved channel for the New River would extend from the mouth of Skunk Creek downstream to the confluence with the Agua Fria River, a distance of about 8 miles. The channel, which would be excavated in earth, would have revetted side slopes. The channel would be a trapezoidal section with bottom widths ranging from 400 to 800 feet and depths ranging from 8-1/2 to 11 feet. The design capacity of the channel would range from 53,400 cubic feet per second at the U.S. Highway No. 60 crossing of the channel to 58,000 cubic feet per second at the mouth of the New River. The Sante Fe railroad, the U.S. Highway No. 60, and the Glendale Avenue bridges would require modification. Four dip crossings would be required - one each at Thunderbird Road and Peoria, Northern, and Olive Avenues.

(n) Agua Fria channel improvement.--An excavated earth channel would be constructed in the Agua Fria River for a distance of 7-1/2 miles from the mouth of the New River to a point about 2 miles downstream (south) of the bridge for U.S. Highway No. 80. The channel, which would be trapezoidal in cross section, would be lined with stone on the side slopes. The channel would have base widths ranging from 800 to 1,500 feet and depths ranging from 8-1/2 to 10 feet. The design capacity of the channel would range from 70,000 to 74,000 cubic feet per second.

The channel invert under the bridges would be protected with dumped stone. The channel terminus would be protected against scour by a dumped-stone apron. About 1/2 mile of El Mirage Road would be relocated, and four dip crossings would be required - one each at Van Buren Street and at Indian School, Thomas, and McDowell Roads.

MUTIPLE-PURPOSE FEATURES

77. Under present conditions, water supplies are limited to the natural flows of the streams under consideration. As a result, storage for water conservation or waterpower could not be justified; and fish-and-wildlife or recreational facilities that could be developed would be minor and probably could not be justified because of the low average annual yield of the streams involved and the high evaporation and large infiltration losses that would occur in the reservoir areas. Under present conditions, recreational development at the detention basins probably would be limited to land-based recreation - such as day camping, picnicking, riding, and hiking. Such recreational facilities - if desired by local interests - would be constructed, operated, and maintained by local interests so as to be compatible with the project purpose.

78. However, the Granite Reef aqueduct of the Central Arizona project proposed by the Bureau of Reclamation would cross the New River, Skunk Creek, and Cave Creek in the vicinity of the proposed detention basins. A definite location for this aqueduct has not been determined and all features of the Bureau project have not been firmed. With the importation of Colorado River water to the area, the proposed detention basins probably could be adapted for multiple-purpose use with mutual advantages for the aqueduct facilities of the Central Arizona project; for those future municipal water-supply treatment and distribution facilities of the city of Phoenix that would be supplied by the Central Arizona project; for the recreational plans of the Maricopa County Parks and Recreation Department; and for the fish-and-wildlife facilities to be developed jointly by the Arizona Game and Fish Department and the U.S. Bureau of Sport Fisheries and Wildlife. No detailed studies of fish-and-wildlife or recreational facilities were, therefore, made under present water-supply conditions. The addition of such facilities would not appreciably change the overall conclusions of the report. Modification of the improvements recommended in this report would be made in the definite-project studies after the Central Arizona project plans are firmed, and upon determination of the economic justification of the additional facilities required.

79. The recommended plan could also be modified to permit some floodflows to be delivered to existing canals downstream from the improvements or to water-spreading areas if local interests desire such facilities. The modification could be made at such time as desired by those using agencies of local interests that would be willing to pay the added expense. All lands for construction of improvements under the recommended plan would be supplied by local interests. These lands would be administered by local interests in connection with their operation and maintenance of the project.

ESTIMATES OF FIRST COST AND ANNUAL CHARGES

80. Estimates of first cost.--The estimated first cost of the improvements include expenditures for construction of four detention basins and seven channel improvements; for relocation or modification of roads, utilities, and bridges; and for acquisition of rights-of-way. Estimates of cost were based on prices prevailing in October 1963. Allowances were made for the cost of engineering, overhead, inspection, and contingencies.

81. Details of the estimated first cost of the improvements under the recommended plan are given in appendix 3. A summary of these costs is given in the following table:

Estimated first costs of improvements under the recommended plan, Phoenix, Ariz., and vicinity (including New River) based on October 1963 prices

Unit of Improvement	Federal first cost	Non-Federal first cost	Total first cost*
Cave Buttes detention basin	$6,490,000	$260,000	$6,750,000
Cave Creek channel	1,840,000	60,000	1,900,000
Union Hills diversion channel	7,200,000	1,300,000	8,500,000
Dreamy Draw detention basin	330,000	130,000	460,000
Dreamy Draw channel	820,000	80,000	900,000
Arizona Canal diversion channel	11,400,000	4,200,000	15,600,000
Adobe detention basin and channel	3,800,000	850,000	4,650,000
Skunk Creek channel	7,100,000	360,000	7,460,000

* Does not include $275,000 expended for preauthorization studies.

Estimated first costs of improvements under the recommended plan, Phoenix, Ariz., and vicinity (including New River) based on October 1963 prices--Continued

Unit of Improvement	Federal first cost	Non-Federal first cost	Total first cost*
New River detention basin	$2,900,000	$480,000	$3,380,000
New and Agua Fria Rivers channel improvements	17,800,000	3,400,000	21,200,000
Total	59,680,000	11,120,000	70,800,000

* Does not include $275,000 expended for preauthorization studies.

82. Estimates of annual charges.--The estimates of annual charges for the improvements considered in this report reflect (a) interest on the total investment, (b) amortization of the total investment in 100 years, and (c) average annual costs of maintenance and operation. The annual charges were computed by using a 3-percent interest rate on both the Federal and non-Federal investments. Because the non-Federal interest rate used is less than the fair rate of return (6 percent) of land in the area, an adjustment of 3 percent was made for the net loss of productivity of land to be used for the improvement.

83. Interest during construction was based on the estimated time of construction of each item in the improvement plan as shown in appendix 3. No interest was charged for items with a construction period of 1 year or for the channels along the Agua Fria and the New Rivers and along Skunk Creek. It was considered that benefits would accrue to these items as construction proceeded. Interest on the other items was charged at 3 percent.

84. Estimates of investments and of average annual charges for the recommended plan are given in the following table:

Estimated total investment and annual charges, improvements under recommended plan, Phoenix, Ariz., and vicinity (including New River) based on October 1963 prices

(a)	Federal investment:	
(1)	First cost	$59,680,000
(2)	Interest during construction	1,210,000
(3)	Total Federal investment	60,890,000
(b)	Federal annual charges:	
(1)	Interest, 3 percent on item (a) (3)	1,827,000
(2)	Amortization of Federal investment in 100 years at 3 percent, 0.001647 times item (a) (3)	100,000
(3)	Total Federal annual charges	1,927,000
(c)	Non-Federal investment:	
(1)	First cost	11,120,000
(2)	Interest during construction	510,000
(3)	Total non-Federal investment	11,630,000
(d)	Non-Federal annual charges:	
(1)	Interest, 3 percent of item (c) (3)	350,000
(2)	Amortization of non-Federal investment in 100 years at 3 percent, 0.001647 times item (c) (3)	19,000
(3)	Net loss of productivity of land (.06-.03) times cost of rights-of-way not including acquisition costs	212,000
(4)	Maintenance and operation	228,000
(5)	Total non-Federal annual charges	809,000
(e)	Total annual charges:	
(1)	Federal	1,927,000
(2)	Non-Federal	809,000
(3)	Total annual charges	2,736,000
(4)	Say	2,740,000

ESTIMATE OF BENEFITS

85. Tangible benefits.--Tangible benefits would accrue from the prevention of flood damages under the recommended plan of improvement. In addition, benefits would also accrue to the recommended improvements from an increase in the utilization of land in the overflow area. No benefits from water conservation, hydroelectric power, or water-based recreation would result from the improvements. Additional information on the development of benefits is given in appendix 4. Pertinent information on tangible benefits is given in the following subparagraphs.

(a) Benefits from flood damages prevented.--Construction of improvements under the recommended plan would provide a high degree of protection to lands and improvements along Dreamy Draw, Cave Creek, and Skunk Creek, along the New River and the Agua Fria River, and to property subject to sheet flow originating in the lower Deer Valley area. Those floodflows up to the capacity of the channels that originate upstream from the Arizona Canal (from 12th Street to the New River) and upstream from the Union Hills channel (from about 40th Street to Skunk Creek) would be controlled and conveyed to the Gila River. Within the protected area, average annual damages prevented are estimated at about $7,750,000, which is about 89 percent of the total average annual potential damage. The flood-control channels would also provide outlets for all storm-drainage works that may be constructed by local interests in the area.

(b) Benefits from increased utilization of land.--Benefits from increased utilization of land were estimated to accrue to about 1,840 acres of land in the overflow area of Cave Creek, generally east of the main stream and south of Bell Road. This area, about 2-1/2 miles long and 1 mile wide, is presently desert land dissected by numerous washes and is not suitable for development without substantial expenditures for flood control. To provide protection from even small floods, large amounts of fill material would be required to bring building floor levels above flood level. Even with such filling, the area would still be subject to damage from larger floods.

(c) With flood protection, this area would be suitable for residential and commercial development similar to such development in other areas nearby. Although alternative locations now exist for the development expected on this land, it is considered that the rapid and continuing growth of the Phoenix metropolitan area will require the complete utilization of the existing land resources over the next 20 years. The land-enhancement benefits accruing from the proposed improvement would be the difference between the market value of the unimproved land if all informed buyers and sellers expected no flood protection and the market value of the unimproved land if all informed buyers and sellers expected flood protection.

(d) Detailed studies were made of the value of land - both inside and outside the area - that would be protected by the proposed improvement. It is estimated that the land would increase in value from an average of $2,500 per acre under present conditions to $8,000 per acre with flood control, an increase of $5,500 per acre. It is estimated that the land would reach complete development within 20 years; the total increase of value is estimated at $10,100,000. The annual return at 6 percent interest, on the present worth of the land-value increase due to estimated land enhancement, would be the average annual land-enhancement benefit, which was computed to be $460,000.

86. Intangible benefits.--Many benefits not susceptible of monetary evaluation would accrue from the operation of the improvements considered in this report. Such benefits would include reduction of the danger of loss of life from floods. Loss of life has occurred in the Phoenix area in previous floods and, with the rapidly increasing development in the overflow area, the danger of loss of life is increasing.

87. Other intangible benefits would result from (a) the prevention of such interruption of services from the Arizona Canal as would occur when the canal is emptied to perform flood-control diversion during rainstorms or is breeched by floodflows; (b) the reduction of epidemics caused by flood damages to sewer and water systems; (c) the prevention of interruptions to traffic, business transactions, public utilities, home life, and school and other normal community activities; and (d) the preservation of community morale by reducing the fear of floods in the overflow areas.

88. Summary of tangible benefits.--The average annual tangible benefits that would accrue under the recommended plan of improvement are summarized in the following table:

Average annual benefits from flood damages prevented	$7,750,000
Average annual benefits from increased utilization of land	460,000
Total average annual tangible benefits from recommended improvements	8,210,000

89. Summary of economics.--A summary of the economics of the recommended plan of improvement is given in the following table:

Summary of economics for improvements under recommended plan for Phoenix, Ariz., and vicinity (including New River)

Item	Value
Total first cost (October 1963)	$70,800,000
Total annual charges	2,740,000
Average annual benefits	*8,210,000
Benefit-cost ratio	3.0 to 1
Intangible benefits	Large

* Comprising $7,750,000 for flood damages prevented and $460,000 for increased utilization of land.

90. Project formulation.--Construction of the improvements recommended in this report would provide feasible and justifiable protection to a part of metropolitan Phoenix. The area includes an intensively developed residential and commercial section along Cave Creek between the Arizona Canal and the Salt River; a rapidly developing residential and commercial area along Cave Creek between Bell Road and the Arizona Canal; agricultural development along Skunk Creek, along the New River, and along the lower Agua Fria River; and residential and commercial development in the communities of Peoria and Avondale, which are on the New River and the Agua Fria River, respectively.

91. The project was formulated to control as much of the floodflow as possible in the drainage area involved, to divert residual flows in Deer Valley and Cave Creek to Skunk Creek, and to improve Skunk Creek and the New and the Agua Fria Rivers so that they can carry these residual flows to an adequate point of disposal. The recommended detention basins were designed to control a standard project flood. The diversion channels and other improved channels would control all floods up to a design flood, which is expected to occur on an average of about once in every 100 years. Floods of these magnitudes, although only about 46 percent of the uncontrolled standard project flood, are larger than any known flood on record in the metropolitan area. The capacities of the recommended channels would be considerably more than the nondamaging capacity of the existing washes.

92. Selection of the magnitude of the design flood for the recommended improvements was based on economic factors and on the desired degree of protection to be provided. The hazards of loss of life in areas directly downstream from the detention basins and the effects of disruption of community activities on the occurrence of floods are great and support the need for a high degree of protection in the overflow areas to be protected by these improvements. The detention basins control floodflows on the major streams in the area. It is essential to control as

much of such flows as possible so as to decrease the residual flows downstream from the detention basins. The detention basins were, therefore, designed for a standard project flood. The capacity of the recommended channels through the urban areas would be exceeded only on infrequent intervals, and additional flood-control benefits developed by increasing the design discharge from that of a 100-year flood to that of a standard project flood would amount to only $175,000 annually, which is less than 3 percent of the total average annual benefits resulting from flood damage prevented under the recommended plan. The channels through the urban areas have design capacities that are adequate to carry the outflows from the detention basins and, in addition, to control the runoff equal to the magnitude of a 100-year flood from the areas downstream from the detention basins. The channels would be entrenched, thus eliminating the need for levees - whose rupture would create destructive flows. In the event of a flood exceeding the capacity of the channels, overflow would be at shallow depths and modest velocities. In addition, the overflow would not be destructive and should result in little or no threat to life. Increasing the design discharge beyond that need in this report could not be justified by the relatively small additional average annual damages that would be prevented. The degree of protection to be provided is considered reasonable in light of the present and future development expected in the area.

93. Local interests expressed agreement with the recommended plan in that it meets the needs for flood control in the northwest and west part of the Phoenix metropolitan area.

94. The recommended plan would prevent about 89 percent of the total average annual damages in the overflow areas along Dreamy Draw, Cave Creek, Skunk Creek, the New River, and the Agua Fria River. Most of the residual damages would result from excessive flows originating downstream from the proposed works. It is essential that local interests continue to construct storm-drain improvements for the control of local storm waters. The recommended channel improvements, particularly the channels in the New and the Agua Fria Rivers, would provide a major outlet for a local storm-drain system.

95. As discussed under a preceding heading "Multiple-Purpose Features," consideration was given to the development of fish-and-wildlife and recreational facilities at the proposed detention-basin sites. Although these facilities apparently are not justified under present conditions of streamflow, they probably could be incorporated into the project plans with the importation of water from the Colorado River, as proposed by the Bureau of Reclamation's Central Arizona project.

96. Such additional information on the recommended plan as called for by Senate Resolution 148, 85th Congress, 2d session, adopted on January 28, 1958, is contained in a supplement to this report.

RELATIONSHIP OF RECOMMENDED PLAN TO COMPREHENSIVE BASIN PLAN

97. The improvements recommended in this report would be an integral part of the comprehensive plan for flood control in the Phoenix metropolitan area, which in turn would be an integral part of the comprehensive basin plan for the Gila River basin, a unit of the Colorado River basin.

98. The recommended improvement would alleviate a serious local flood problem within the rapidly growing Phoenix metropolitan area. It would (a) provide economically justified flood protection for overflow areas along Dreamy Draw, Cave Creek, Skunk Creek, the New River, the Agua Fria River, and for several unnamed tributary washes and (b) permit higher utilization of about 1,340 acres of land needed for residential and commercial development in the rapidly expanding area of Deer Valley, east of the main Cave Creek channel. Removal of the flood hazard by the recommended improvements would also permit optimum development of the remaining open areas in this fast-growing area. The flood problem in the Phoenix metropolitan area is not interconnected with flood problems in other parts of the Gila River basin.

99. The proposed Central Arizona project of the Bureau of Reclamation includes an aqueduct that would pass through the Cave Creek, Skunk Creek, and the New River drainage areas. To provide flood protection to the aqueduct, the Bureau is considering protective works upstream from the aqueduct. The exact location of the aqueduct or the required protective works has not been determined. Should the Central Arizona project be authorized by Congress, the required flood-protective works would be coordinated with the recommended plan and integrated into the comprehensive plan for the area.

100. The recommended plan would provide needed flood protection to the Arizona Canal, one of the main irrigation canals in the Salt River Valley. Interruption of delivery of irrigation water would be lessened considerably with resultant beneficial effects on the economy and morale of the valley. In addition, several elements of the plan could be used as outlet channels for storm drains constructed by local interests.

PROPOSED LOCAL COOPERATION

101. The local cooperation that would be required for the project is based on the requirements of applicable laws. As a requisite to construction of improvements by the United States under the recommended plan, responsible local interests would be required to:

(a) Provide - without cost to the United States - all lands, easements, and rights-of-way necessary for the construction and subsequent maintenance and operation of the project, at a cost estimated at $7,320,000.

(b) Perform - without cost to the United States - all necessary construction or relocation of highways, roads, bridges, utilities, and all necessary street modifications required in connection with the project, at a cost estimated at $3,800,000.

(c) Hold and save the United States free from damages due to the construction works.

(d) Maintain and operate all the works, after completion, in accordance with regulations to be prescribed by the Secretary of the Army, at an average annual cost estimated at $228,000.

(e) Prevent any encroachment upon the improved channels or within the detention-basin areas that would reduce their flood-conveying or storage capacities.

(f) Hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the project.

102. An analysis of the land-enhancement benefits indicates that no windfall benefits would accrue to any one individual or group. The 1,840 acres subject to land enhancement are now owned by about 100 different individuals. At the time of full development of the area, it is estimated that as many as 5,000 owners would be in the area. It is, therefore, considered that no local contribution, because of benefits from land enhancement, is required.

103. The Board of Directors of the Flood Control District of Maricopa County, Ariz., by resolution dated November 7, 1963, indicated a willingness to provide the items of local cooperation previously listed. A copy of the resolution is included in Appendix 6: Resolution by Local Interests. Available information indicates that the Board of Directors of the Flood Control District of Maricopa County has the legal authority to meet the specified local-cooperation requirements. Their financial ability is probably dependent upon approval of a bond issue for the purpose.

104. The Department of Commerce has informed the Chief of Engineers that Federal-aid highway funds are not available to defray any part of the costs of altering Federal-aid highways for flood-control projects, where local interests are required to assume the cost of such adjustment as part of the local-cooperation requirements.

COORDINATION WITH OTHER AGENCIES

105. The flood problem and possible measures for preventing flood damages in Phoenix, Ariz., and vicinity (including New River) were discussed with representatives of the city of Phoenix, Maricopa County including the Flood Control District of Maricopa County, the State of Arizona, interested Federal agencies, and private individuals.

106. A meeting was held in Phoenix, Ariz., on October 30, 1963, to present the proposed plan of improvement to local interests and to Federal and State agencies, to ascertain their views, and to insure that the recommended plan would be an integral part of the comprehensive plan for flood protection in the Phoenix metropolitan area.

107. Draft copies of this report were submitted to all Federal and State agencies known to have an interest in the investigation. Comments received from those agencies and replies by the U.S. Army Engineer District, Los Angeles, where pertinent, are inclosed in appendix 5. Plans for the recommended improvement do not conflict with the plans of other Federal or non-Federal agencies. A summary of significant comments is given in the following subparagraphs.

(a) The Bureau of Land Management noted that the program of flood-control improvements would not seriously affect the management of public land in the area. The Bureau did state, however, that it was possible that their land-disposition program might be affected indirectly because access to these lands may be removed by construction of the project. The reply by the U.S. Army Engineer District, Los Angeles, indicated that, after a definite location of the improvement was established during the detailed design studies, the problem of access to public lands would be resolved. The Bureau also commented on the need for expansion of wildlife habitat and a retention of dead-water storage for the benefit of game birds. A detailed study of this aspect of the improvement will be made during the detailed design studies after authorization of the project.

(b) The Bureau of Public Roads affirmed the statement in the report that Federal-aid highway funds are not available for use on highways or bridges built or reconstructed as part of the local-cooperation requirements.

(c) The Bureau of Mines noted that the area has a low potential for minerals other than sand and gravel and that possible loss of mineral reserve because of the project would be negligible.

(d) The Bureau of Reclamation commented that the recommended plan of improvement would alleviate a serious local flood problem within the rapidly growing Phoenix metropolitan area. The Bureau

noted that the Granite Reef aqueduct of the Central Arizona project, proposed by the Bureau of Reclamation, would cross the New River and Skunk and Cave Creeks. The Bureau further expressed the opinion that these proposed flood-control facilities could be adapted for multiple-purpose use with mutual advantages for the Central Arizona project aqueduct facilities; for the future municipal water-supply treatment and distribution facilities of the city of Phoenix, to be supplied from the proposed Central Arizona project; and for the recreational plans of the Maricopa County Parks and Recreation Department. The Bureau indicated that, after the Central Arizona project aqueduct plans are firmed, any conflict in location between the features of the Central Arizona project and the flood-control program proposed in this interim report would be adjusted and the best overall plan adopted by all interested parties.

(e) The U.S. Fish and Wildlife Service agreed that the improvements proposed in this report would provide a large measure of flood protection to portions of metropolitan Phoenix. The Service concluded that the project would result in some wildlife-habitat losses that would be compensated, in part, by increased amounts of wildlife-food plants in the floodwater-detention basins and that no hunting benefits would be realized. The Service recommended that additional study be made to determine the feasibility of including provision for future storage in the Adobe, the Cave Buttes, and the lower New River detention basins for development of fishery pools. In reply, the U.S. Army Engineer District, Los Angeles, presented the information now included under a preceding heading "Multiple-Purpose Features." The Service was also advised that serious consideration would be given in developing detailed plans to providing a minimum disturbance of trees and shrubs, as recommended in their report.

(f) The Federal Power Commission indicated that the development of hydroelectric power in connection with the proposed improvements would not be economically feasible.

(g) The U.S. Forest Service found that approximately 30 percent of the drainage area upstream from the proposed flood-control structures is within the Tonto and Prescott National Forests. The Service noted that their management of those lands is a vital part of the overall flood-prevention effort and would enhance the value of the proposed flood-control project.

(h) The National Park Service was pleased to learn that, although water-based recreation is not a purpose of the project, some recreational development and use of the project area could be made by local interests. The Service also stated that, if the project is authorized, arrangements would be made for an archeological survey and necessary salvage.

(i) The U.S. Public Health Service recommended certain principles and practices in the design, construction, operation, and maintenance of the proposed project to minimize conditions that would increase populations of mosquitoes. The Service also made recommendations regarding the relocation of water mains and the treatment of wells. These recommendations would be considered in later studies and during construction of the project.

(j) The area hydrologic engineer of the U.S. Weather Bureau indicated that, because of the erratic nature of flash-flood-producing storms and the limited time between rainfall and runoff, it would be impracticable to provide adequate warning service of possible floods. He further indicated that the recommended project should provide needed protection from serious flooding in the metropolitan Phoenix area.

(k) The Arizona Game and Fish Department pointed out that some provision should be made in initial planning to allow for future consideration and possible expansion of fish and wildlife in the event a conservation pool is feasible. The Department indicated that the possibility of water-conservation storage in the Cave Buttes and the New River detention basins should not be overlooked. The Department also expressed concern regarding the elimination of vegetative growth and subsequent wildlife-habitat losses within the detention basins and along the water courses; in reply, the U.S. Army Engineer District, Los Angeles, indicated that serious consideration would be given in the development of detailed plans to provide a minimum disturbance of trees and shrubs. In reply to the other comments of the Department, the U.S. Army Engineer District, Los Angeles, presented information that is included under a preceding heading "Multiple-Purpose Features."

(l) The representative of the Governor of Arizona for flood-control matters concurred with the recommendation as expressed in this report. He indicated that the project has been shown to be economically feasible and conforms to the interests and needs of the Phoenix area. He stated that the State Land Department would cooperate with local interests in obtaining rights-of-way for the project and that the Arizona Highway Department would cooperate in the preparation of plans for proposed crossings of State highways. He pointed out, however, that the Arizona Game and Fish Department is concerned over the effect of the program on wildlife and is interested in the development of recreational areas. With reference to the wildlife and recreational aspects of the program, the reply of the U.S. Army Engineer District, Los Angeles, presented information that is included under a preceding heading "Multiple-Purpose Features."

(m) The Department of Water Resources of the Resources Agency of the State of California and the Colorado River Board of California indicated that the interest of the State of California in the Colorado River would not appear to be prejudiced by the proposed developments.

CONCLUSIONS

108. The district engineer concludes that:

(a) A serious flood problem exists along Dreamy Draw, Cave Creek, Skunk Creek, and along the New and the Agua Fria Rivers where intensively developed urban and agricultural areas, within and adjacent to the city of Phoenix, Ariz., are subject to damage by floods.

(b) The danger of loss of life and the menace to health by floods in the area are great.

(c) Without additional flood control, a large area of land adjacent to Cave Creek would not be developed to its full potential.

(d) Economically feasible protection can be provided by the construction of (1) the Cave Creek, the Skunk Creek, the New River, and the Dreamy Draw Dams; (2) the Union Hills and the Arizona Canal diversion channels; and (3) the Cave Creek, the Dreamy Draw, the Skunk Creek, the New River, and the Agua Fria River channel improvements. The proposed improvement would prevent 89 percent of the potential flood damages in the area and permit higher land use on about 1,340 acres of land.

(e) The proposed plan is an integral part of the comprehensive flood-control plan for the Phoenix metropolitan area and would be a unit of the comprehensive plan for overall development of the Gila River basin.

(f) The total first cost of the recommended improvements is estimated at $70,800,000 (October 1963 prices). Based on estimates of average annual charges of $2,740,000 and average annual tangible primary benefits of $8,210,000, the benefit-cost ratio would be 3.0 to 1.

(g) The recommended improvement is feasible from an engineering standpoint, is well justified economically by the tangible benefits alone, and is further justified by significant intangible benefits.

(h) Detailed consideration should be given to modifying the recommended detention basins to incorporate fish-and-wildlife and recreational facilities after plans of the Central Arizona project, proposed by the U.S. Bureau of Reclamation, are firmed.

RECOMMENDATIONS

109. The district engineer recommends:

(a) That the United States adopt a project for the control of floods along Cave Creek and its tributaries and along Skunk Creek, the New River, and the Agua Fria River in and adjacent to the metropolitan Phoenix area, at an estimated total first cost of $70,800,000 (October 1963 prices) and an average annual cost of $228,000 for operation and maintenance.

(b) That construction of the recommended improvements, at a total estimated cost to the United States of $59,680,000 (October 1963 prices), be subject to the condition that local interests supply assurances satisfactory to the Secretary of the Army that they will (1) provide - without cost to the United States - all lands, easements, and rights-of-way necessary for the construction and subsequent maintenance and operation of the project, at a cost estimated at $7,320,000; (2) perform - without cost to the United States - all necessary construction or relocation of highways, roads, bridges, utilities, and all necessary street modifications required in connection with the project, at a cost presently estimated at $3,800,000; (3) hold and save the United States free from damages due to the construction works; (4) maintain and operate all the works, after completion, in accordance with regulations to be prescribed by the Secretary of the Army, at an average annual cost estimated at $228,000; (5) prevent any encroachment upon the improved channels or within the detention-basin areas that would reduce their flood-conveying or storage capacities; and (6) hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the project.

(c) That the recommended detention basins be modified to provide fish-and-wildlife and recreational facilities upon the finding of economic justification by the Corps of Engineers in cooperation with appropriate State and Federal agencies.

A. R. Marshall

6 Appendixes
(See table of contents.)

A. R. MARSHALL
Lt. Col., Corps of Engineers
Acting District Engineer

SPDGP (15 Jan 64) 1st Ind
SUBJECT: Interim Report on Survey for Flood Control, Phoenix, Ariz., and Vicinity (Including New River), Gila River Basin, Ariz.

U S Army Engr Div, South Pacific, San Francisco, Calif 12 Feb 1964

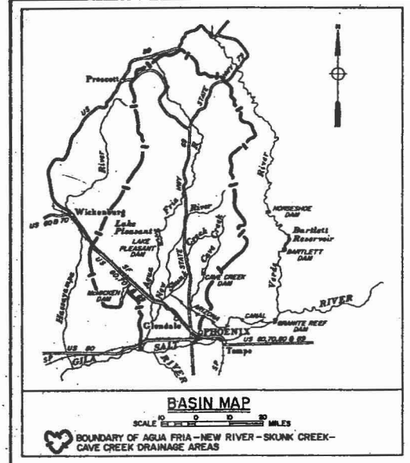
TO: Chief of Engineers

I concur in the conclusions and recommendations of the District Engineer.

6 Incl
n/c

ARTHUR H. FRYE, JR.
Brigadier General, U. S. Army
Division Engineer

U.S. ARMY ENGINEER DISTRICT — CORPS OF ENGINEERS



BASIN MAP

SCALE 0 10 20 MILES

BOUNDARY OF AGUA FRIA–NEW RIVER–SKUNK CREEK–CAVE CREEK DRAINAGE AREAS

LEGEND FOR COMPREHENSIVE PLAN

PHASE A
- CHANNEL PREVIOUSLY RECOMMENDED

PHASE B
- RECOMMENDED CHANNEL
- RECOMMENDED DETENTION BASIN
- CONSIDERED DETENTION BASIN
- RECOMMENDED LEVEE

PHASE C
- CHANNEL
- DETENTION BASIN

PHASE D
- CHANNEL
- RESERVOIR

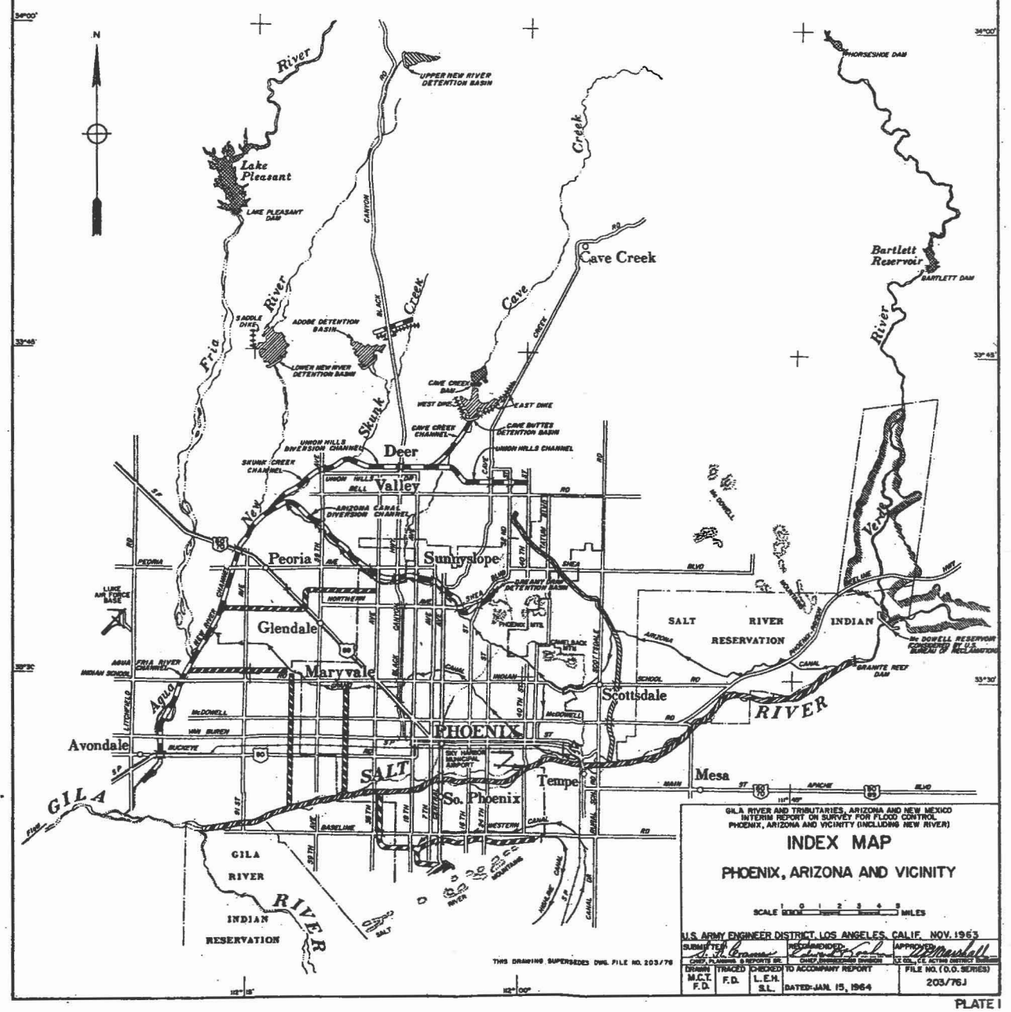
PHASE E
- CHANNEL

EXISTING RESERVOIR

VICINITY MAP

SCALE 50 0 50 100 150 200 MILES

BOUNDARY OF GILA RIVER DRAINAGE AREA
AREA COVERED BY MAP



GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)

INDEX MAP

PHOENIX, ARIZONA AND VICINITY

SCALE 0 1 2 3 4 5 MILES

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF. NOV. 1963

SUBMITTED	RECOMMENDED	APPROVED
Chief, Planning & Reports Br.	Chief, Engineering Division	Lt. Col., CE, Acting District Engineer

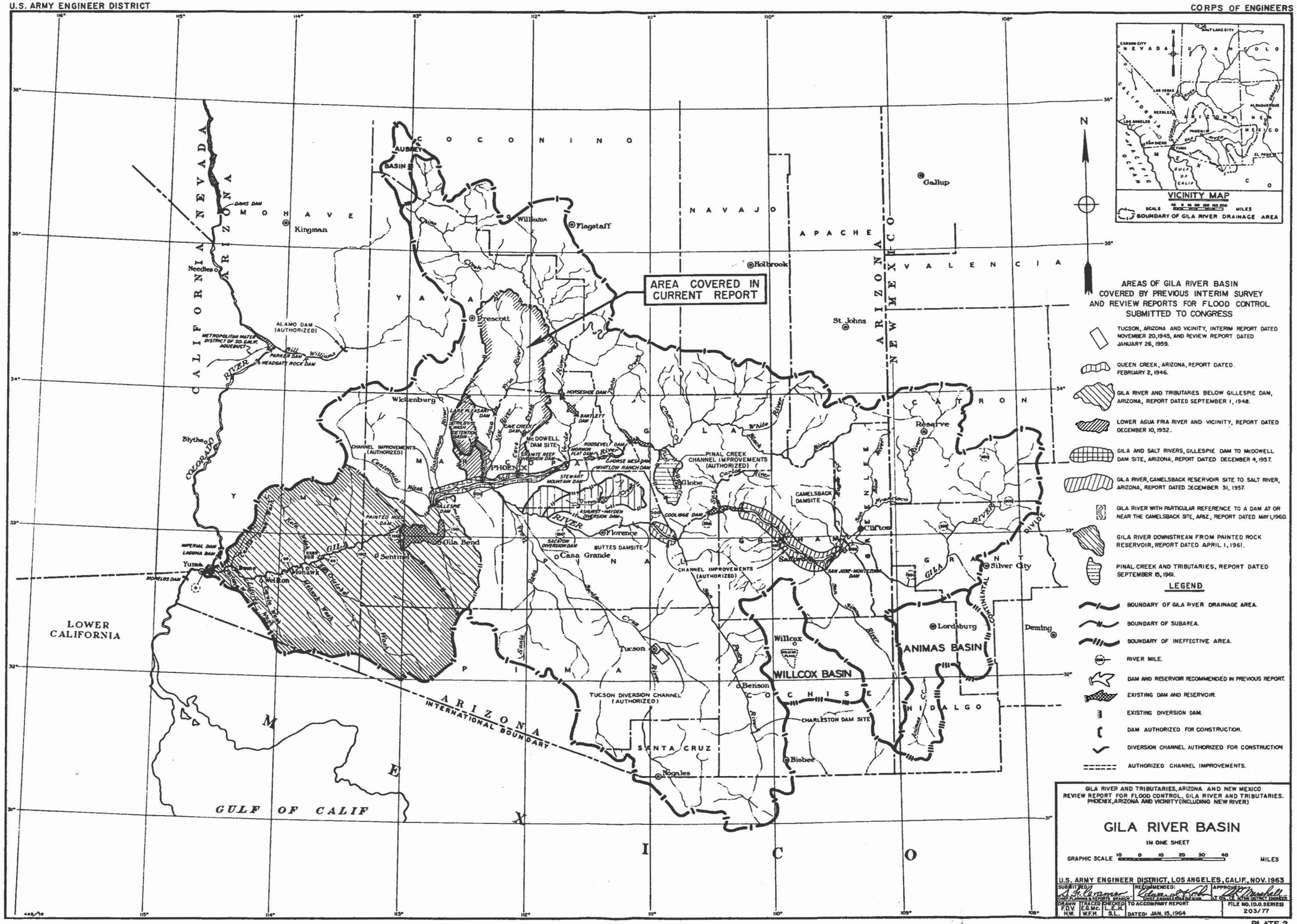
DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (O.O. SERIES)
M.C.T. F.D.	F.D.	L. E.H. S.L.	DATED: JAN. 15, 1964	203/76J

THIS DRAWING SUPERSEDES DWG. FILE NO. 203/76

PLATE I

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



AREAS OF GILA RIVER BASIN COVERED BY PREVIOUS INTERIM SURVEY AND REVIEW REPORTS FOR FLOOD CONTROL SUBMITTED TO CONGRESS

TUCSON, ARIZONA AND VICINITY, INTERIM REPORT DATED NOVEMBER 20,1945, AND REVIEW REPORT DATED JANUARY 26, 1959.

QUEEN CREEK, ARIZONA, REPORT DATED FEBRUARY 2, 1946.

GILA RIVER AND TRIBUTARIES BELOW GILLESPIE DAM, ARIZONA, REPORT DATED SEPTEMBER 1, 1948.

LOWER AGUA FRIA RIVER AND VICINITY, REPORT DATED DECEMBER 10, 1952.

GILA AND SALT RIVERS, GILLESPIE DAM TO McDOWELL DAM SITE, ARIZONA, REPORT DATED DECEMBER 4, 1957.

GILA RIVER, CAMELSBACK RESERVOIR SITE TO SALT RIVER, ARIZONA, REPORT DATED DECEMBER 31, 1957.

GILA RIVER WITH PARTICULAR REFERENCE TO A DAM AT OR NEAR THE CAMELSBACK SITE, ARIZ., REPORT DATED MAY 1, 1960.

GILA RIVER DOWNSTREAM FROM PAINTED ROCK RESERVOIR, REPORT DATED APRIL 1, 1961.

PINAL CREEK AND TRIBUTARIES, REPORT DATED SEPTEMBER 15, 1961.

LEGEND

- BOUNDARY OF GILA RIVER DRAINAGE AREA.
- BOUNDARY OF SUBAREA.
- BOUNDARY OF INEFFECTIVE AREA.
- RIVER MILE.
- DAM AND RESERVOIR RECOMMENDED IN PREVIOUS REPORT.
- EXISTING DAM AND RESERVOIR.
- EXISTING DIVERSION DAM.
- DAM AUTHORIZED FOR CONSTRUCTION.
- DIVERSION CHANNEL AUTHORIZED FOR CONSTRUCTION
- AUTHORIZED CHANNEL IMPROVEMENTS.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
REVIEW REPORT FOR FLOOD CONTROL, GILA RIVER AND TRIBUTARIES.
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)

GILA RIVER BASIN

IN ONE SHEET

GRAPHIC SCALE 10 0 10 20 30 40 MILES

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF., NOV. 1963

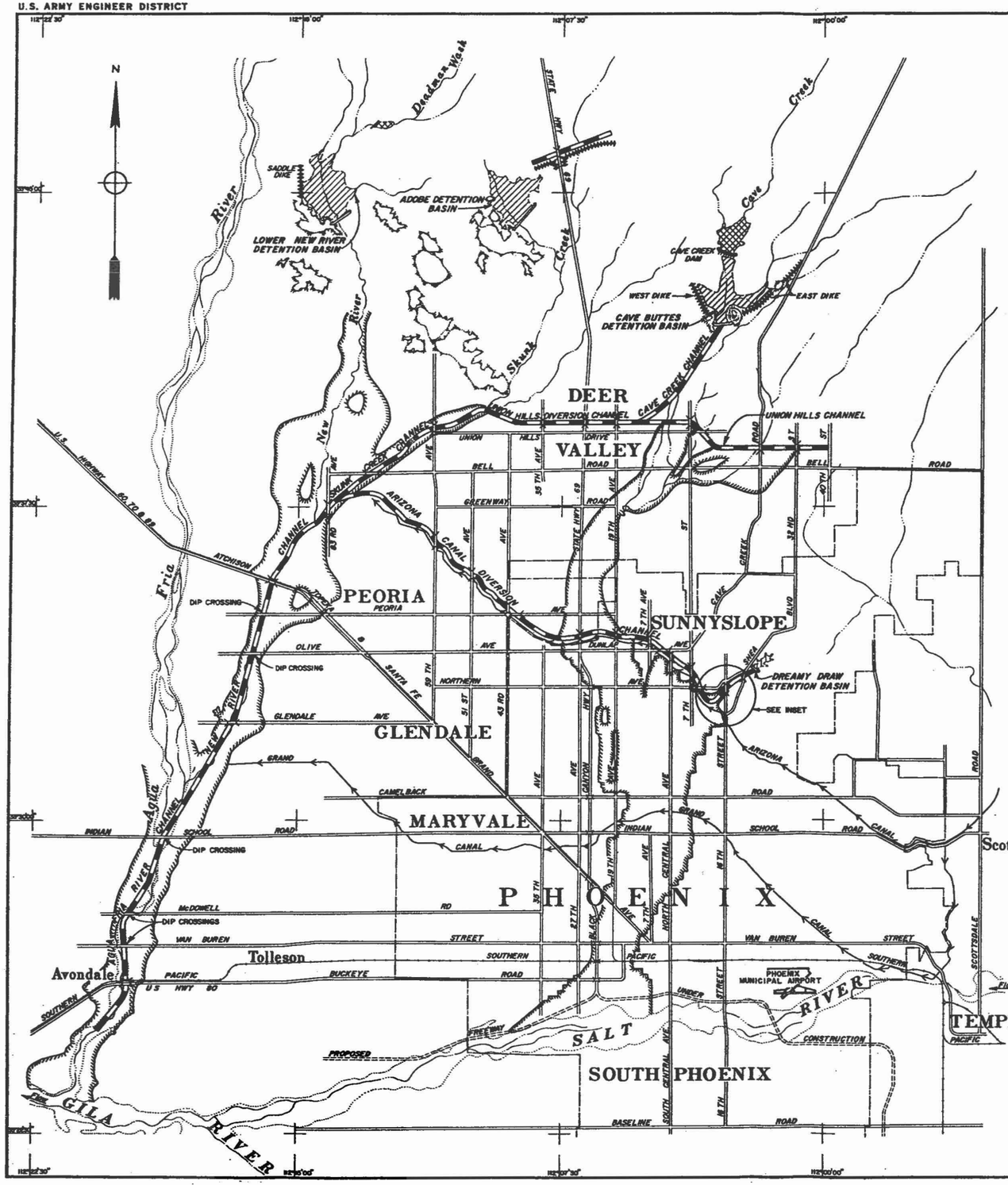
SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, PLANNING & REPORTS BRANCH	CHIEF, CONSTRUCTION DIVISION	LT. COL., CE, DISTRICT ENGINEER

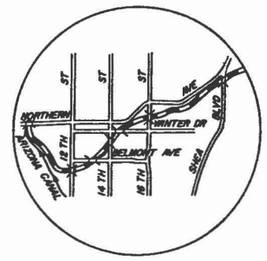
DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (D.D. SERIES)
F.D.V.	E.S.M.C.	L.E.H.	DATED: JAN. 15, 1964	203/77
H.W.	W.F.H.	S.L.		

PLATE 2

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS





INSET

LEGEND

- BOUNDARY OF AREA SUBJECT TO OVERFLOW
- RECOMMENDED CHANNEL
- RECOMMENDED LEVEE
- RECOMMENDED DETENTION BASIN
- EXISTING RESERVOIR

THIS DRAWING SUPERSEDES DWG. FILE NO. 203/78

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY (INCLUDING NEW RIVER)

OVERFLOW AREA AND RECOMMENDED PLAN OF IMPROVEMENT

IN ONE SHEET

SCALE 0 1 2 3 4 MILES

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF. NOV. 1963

SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, PLANNING & REPORTS BRANCH	CHIEF, ENGINEERING DIVISION	LT. COL., CE, ACTING DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (S. O. SERIES)
R.D.	F.D.	L.E.H. B.L.	DATED: JAN. 15, 1964	203/79.1

PLATE 3

APPENDIX 1 - HYDROLOGY

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

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2.	Topography and drainage area map.
3.	Streambed profiles.
4.	Isohyets, total storm precipitation, storm of January 14-21, 1916.
5.	Isohyets, total storm precipitation, storm of August 26-29, 1951.
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18.	Hydrograph, maximum probable flood, Dreamy Draw detention basin.
19.	Inflow-sediment relationship for conservation reservoirs in southwestern United States.
20.	Enveloping curves of peak discharges, streams in Arizona and New Mexico.

HYDROLOGY

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

SCOPE

1. This appendix contains descriptions of studies made to determine the standard project flood and to estimate the maximum probable flood and sediment storage pertinent to the flood-control planning discussed in the main report. The boundaries of the drainage area and drainage subareas and the recommended detention basins, channel improvements, and diversions are shown on plates 1 and 2. Locations for which standard project floods were determined and the locations for which estimates of maximum probable flood and sediment storage were made are given in the following table:

Pertinent information on estimates at various concentration points, Phoenix, Ariz., and vicinity (including New River)

No.*	Location	Drainage area	Type of estimate
		Square miles	
	Agua Fria River:		
1	At Gila River	**2,610.0	Peak discharge.#
2	Downstream from confluence with New River.	**2,570.0	Do.#
	New River:		
3	At Agua Fria River	**640.0	Do.#
4	At U.S. Highway No. 60	**595.0	Do.#
5	Downstream from confluence with Skunk Creek.	**587.0	Do.#
6	At New River detention basin.	170.0	Flood hydrographs, sediment storage.##
	Skunk Creek:		
7	Downstream of Arizona Canal diversion channel.	**398.0	Peak discharge.#
8	Upstream of Arizona Canal diversion channel.	**348.0	Do.#
9	Downstream of Union Hills diversion channel.	**333.0	Do.#
10	At Adobe detention basin	82.5	Flood hydrographs, sediment storage.##
	Union Hills diversion channel:		
11	At Skunk Creek	**224.0	Peak discharge.#
12	West of Cave Creek	**214.0	Do.#
13	3 miles east of Cave Creek	**12.6	Do.#

See footnotes at end of table.

Pertinent information on estimates at various concentration points, Phoenix, Ariz., and vicinity (including New River)--continued

No.*	Location	Drainage area	Type of estimate
		Square miles	
	Cave Creek:		
14...	At Union Hills diversion channel.	200.0	Peak discharge.#
15...	Downstream of Cave Buttes detention basin.	193.0	Do.#
15a..	At Cave Buttes detention basin.	193.0	Flood hydrographs, sediment storage.##
	Arizona Canal diversion channel:		
16...	At Skunk Creek.....	**49.5	Peak discharge.#
17...	West of Cave Creek.....	**29.0	Do.#
18...	At 19th Avenue.....	**6.5	Do.#
	Dreamy Draw:		
19...	At Arizona Canal.....	2.7	Do.#
20...	Downstream of Dreamy Draw detention basin.	1.3	Do.#
20a..	At Dreamy Draw detention basin.	1.3	Flood hydrographs, sediment storage.##

* Concentration point numbers; see pl. 2 for location.

** Assumed contributing drainage area, including total drainage area above diversion channels.

Standard-project-flood peak discharge only was required.

Standard-project- and maximum-probable-flood hydrographs were required.

GENERAL DESCRIPTION OF DRAINAGE AREA

2. Physiographic characteristics.--The Phoenix, Ariz., and vicinity area (including New River) is in Maricopa and Yavapai Counties in the central part of Arizona (see pl. 1), and comprises approximately 2,610 square miles. The basin is generally oval in shape with a maximum length and width of approximately 90 and 45 miles, respectively. Approximately 70 percent of the drainage area is mountainous and the remaining 30 percent is valley area. The mountain areas are characterized by rugged terrain and steep gradients; the lower areas consist of fairly flat valley land with regular alluvial slopes. Elevations in the area range from about 7,000 feet above mean sea level in the headwaters to about 900 feet at the Gila River. The main streams are the Agua Fria and the New Rivers and Skunk and Cave Creeks. The length of the main watercourse, the Agua Fria River, is approximately 115 miles. The main tributary, the New River, has a length

of approximately 48 miles. The gradient of the Agua Fria River ranges from about 300 feet per mile in the headwaters to about 70 feet per mile at the canyon mouth and to about 10 feet per mile at the Gila River. A series of variable length, parallel, intermittent streams descend the slopes of the mountains to the valley where, in many cases, the watercourses are not well defined and the flow is across the developed valley areas to the Salt and Gila Rivers. The valley area includes the cities of Phoenix and Glendale and several small communities. The suburban developments are increasing rapidly. Streambed profiles above the recommended detention basins are shown on plate 3. There is not enough topographical data for the Dreamy Draw drainage area to determine a streambed profile. The estimated gradient of the stream upstream of Dreamy Draw detention basin is approximately 280 feet per mile.

3. The rock materials in the mountains vary widely. The materials include fine-grained, coarse-grained, and metamorphosed granites, including gneiss and schist; sandstones, breccias, and metamorphosed sedimentary rocks; and various lava rocks, including basalt, andesite, rhyolite, volcanic glass, and white tuff. The soils are typical of desert and semidesert regions, being mostly shallow, rocky, and poorly developed. The soils in the mountains are residual. The valley area occupies a broad plain that has been built up from water-deposited soil-forming materials and rock debris. These soils consist of various forms of clays and loams. The soils range from coarse material in the upper parts to fine material in the lower parts of the area. The soils in the lower foothill and valley areas are alluvial and in some places are fairly well developed.

4. In general, the vegetation is sparse. Cacti grow throughout the area along with other desert shrubs on the fairly level areas at the lower elevations. A few stunted trees, including juniper, paloverde, mesquite, ironwood, and scrub oak, are among the shrubs. The vegetation tends to be thicker along and adjacent to the stream courses. Perennial grasses form a negligible part of the vegetation, but good covers of annual grasses occur after the winter rains. The natural vegetation is rapidly being replaced by suburban development, including residential, commercial, and industrial areas in the foothills and valleys.

5. Hydrometeorological characteristics.--The climate is typically desert in character, with short, mild winters and long, hot summers. High diurnal temperature variations are characteristic. The prevailing winds are from the east and are usually light, although severe windstorms occur at rare intervals. The 90-year (1868-1957) mean annual precipitation ranges from about 24 inches in the headwaters to about 7.5 inches in the lower portion and averages about 14.5 inches. (See pl. 1.) Precipitation is divided about equally between the summer and winter seasons.

6. Three types of storms produce precipitation in the general area: general winter storms, general summer storms, and local thunderstorms. A brief description of each storm type is given in the following subparagraphs.

(a) General winter storms usually occur during the period from December to March, inclusive. They originate over the Pacific Ocean as a result of the interaction between polar Pacific and tropical Pacific airmasses and move eastward over the basin. These storms, which often last for several days, reflect orographic influences and are accompanied by widespread precipitation in the form of snow or rain.

(b) General summer storms usually occur during the period from July to September, inclusive. They are associated with an influx of tropical maritime air originating over the Gulf of Mexico or the south Pacific Ocean and entering the area from a southeast to a southwest direction. Usually the influx of tropical air is caused by the circulation around a high-pressure area centered in southeastern United States, but occasionally it is caused by remnants of a tropical hurricane. General summer storms are often accompanied by relatively heavy precipitation over large areas for periods up to 24 hours, but showers may continue for as long as 3 days.

(c) Local thunderstorms can occur at any time of the year, either during general storms or as isolated phenomena. However, they are most common during the period from July to September, inclusive, when the basin is frequently covered by moist, unstable air originating over the Gulf of Mexico. These storms cover comparatively small areas and result in high-intensity precipitation for durations of 3 hours or less.

7. Runoff characteristics.--Little runoff occurs except during and immediately following the heavier precipitation because climatic and drainage-area characteristics are not conducive to continuous runoff. Because of steep gradients, streamflow in the mountains increases rapidly in response to high-intensity precipitation and causes debris-laden floods with high peaks that debouch onto the valley plains below. The percentage of impervious area is increasing appreciably with the rapid suburban development taking place in the area. Vegetation, being sparse, has negligible effect on flood runoff.

8. Existing structures affecting runoff.--The Cave Creek flood-control dam (completed in 1923), which is under the jurisdiction of the Salt River Valley Water Users Association, is about 18 miles north of downtown Phoenix. (See pl. 1.) The original reservoir capacity was approximately 14,000 acre-feet, and in 1948 the capacity was estimated at 11,000 acre-feet. There is no information available on the present capacity. There are three outlets with a total capacity of about 1,600 cubic feet per second with water surface at top of the dam. At the present time, one of the

outlets is ungated and the other two are blocked. The top elevation of the dam is 1,642 feet. The spillway, a natural saddle, is in the hills to the east of the dam and has a crest elevation of 1,638 feet. Cave Creek flood-control dam provides inadequate protection against a standard project flood due to its limited capacity. Lake Pleasant Dam (completed in 1927), which is under the jurisdiction of the Maricopa County Municipal Water Conservation District No. 1, is about 30 miles north-northwest of downtown Phoenix. (See pl. 1.) The present capacity at elevation 170 feet (top of raised spillway gates) is approximately 164,000 acre-feet. McMicken Dam (completed in 1956), which was constructed by the Corps of Engineers about 25 miles northwest of downtown Phoenix (see pl. 1), is under the jurisdiction of Maricopa County Municipal Water Conservation District No. 1. The capacity of the reservoir at spillway crest (elevation 1,354 feet) is approximately 19,300 acre-feet. The capacity of the outlet channel is 14,000 cubic feet per second. There are several irrigation canals with levees in the Phoenix area under the jurisdiction of the Salt River Valley Water Users Association that were constructed in the early 1900's. (See pl. 2.) The Arizona and Grand Canals flow through the city of Phoenix, north of and generally parallel to the Salt River. Their capacities in the vicinity of Cave Creek are approximately 800 and 600 cubic feet per second, respectively. The irrigation canals in the area intercept low flows, but have little effect during high flows. Spillways are usually provided along the canals at the larger washes to permit excessive floods to pass over the canals.

PRECIPITATION AND RUNOFF

9. Precipitation records.--Precipitation records are available for approximately 53 precipitation stations in and near the study area. The longest records are for Prescott, which has 96 years of record during the period 1866-1962; and for Phoenix Post Office, which has 84 years of record during the period 1876-1962, and also a recording-gage record beginning in 1901. The areal coverage of recording precipitation stations is inadequate, as there are only five active stations in the area. The 90-year (1868-1957) mean annual precipitation for the area (see pl. 1) was determined by correlating records at all precipitation stations in the area that had 5 or more years of record with selected base stations in the area. The correlation was based on simple linear regression equations determined by the least squares method. Pertinent data on precipitation stations are given in table 1 and station locations are shown on plate 1.

10. Runoff records.--Runoff records are available for 10 stream-gaging stations in and near the study area. The longest record is for the station on the Agua Fria River at Lake Pleasant Dam, Ariz., which has 34 years of record during the period of 1914-19, 1933-62. Records of discharges during floods are inadequate.

11. Storms and floods of record.--Historical accounts indicate that many damaging floods have occurred in the Gila River basin. Sizable floods were produced by the general storms of February 1884, February 1891, January 1916, and February-March 1938, but available records and estimates of severity are insufficient for detailed analysis for the study area. General winter storms may cause flooding in the study area, but the larger floods generally occur during the summer months as a result of local thunderstorms. Severe local storms and floods occurred in the Phoenix area in 1921, 1935, 1936, 1939, 1943, 1951, 1955, 1956, and 1957. Records for these floods are scarce as are records of other storms that may have occurred in that period. Brief descriptions of the storms and floods of January 1916, August 3, 1943, August 26-29, 1951, September 25-26, 1962, together with the August 19, 1954, storm (southeast of Phoenix), which was used to develop the standard-project-flood hydrology, are given in the following subparagraphs.

(a) Storms and floods of January 1916.--Two general winter storms occurred over the Gila River basin in January 1916. The first storm period extended from January 14-21 and the second from January 25-30. Both storms originated over the Pacific Ocean. Both were centered in the area north of Roosevelt Reservoir, with secondary centers in the Pinal and Santa Catalina Mountains. The second storm had another secondary center in the area tributary to the Agua Fria and the Hassayampa Rivers. The first storm, which was of broader areal extent than the second, produced the larger flood. The isohyetal map on plate 4 shows the area distribution of precipitation that occurred between January 14 and 21. Observed total precipitation at Phoenix for the two storms was only 2.07 inches. Ground conditions were conditioned for runoff owing to the occurrence of precipitation on January 10-12 and to the presence of snow cover over much of the mountain area.

(b) The maximum discharge of the second flood on the Agua Fria River at Lake Pleasant Dam (drainage area, 1,460 square miles) was 105,000 cubic feet per second. On the Salt River near Roosevelt, 17 miles upstream from Roosevelt Dam (drainage area, 4,310 square miles), the peak discharge of the first flood was estimated at 100,000 cubic feet per second.

(c) Storm and flood of August 3, 1943.--The August 3, 1943, flood was caused by heavy precipitation resulting from thunderstorms over the desert areas north and east of Phoenix. Storm conditions started on August 1. Late on August 2, at Tempe, 2.11 inches were recorded in 30 minutes. Heavy precipitation occurred early on August 3. The total precipitation for August 3 was 2.12 inches at Phoenix, 2.99 inches at Phoenix Airport, 3.50 inches at Tempe, and 2.63 inches at Granite Reef Dam. It is likely that more rain than this fell in the desert areas to the north, but no records are available.

(d) Runoff was heavy upstream of the Arizona Canal. A series of 22 breaks occurred in the south-bank levee of the canal in the vicinity of Indian Bend Wash. A break in the south bank of the Arizona Canal in the Cave Creek area released water that caused nine breaks in the Grand Canal. The total peak inflow into the Arizona Canal was estimated at 30,000 cubic feet per second; in Cave Creek upstream of the Arizona Canal, at 9,000 cubic feet per second; and in Indian Bend Wash at the Arizona Canal, at 15,000 cubic feet per second.

(e) Storm and flood of August 26-29, 1951.--A tropical hurricane entered the mainland of Mexico from the east in the vicinity of Tampico on August 22. Moist air associated with this storm (general summer type) crossed Mexico to the eastern coast of the Gulf of California. This moist air began flowing into southwestern Arizona during the 26th, mostly in the vicinity of Organ Pipe Cactus National Monument. By the morning of the 27th, precipitation had become quite general over southern and central Arizona. Heavy precipitation spread northward and northeastward to the northern border of Arizona by the 29th. Precipitation continued moderate to heavy from the 27th through the 29th. The storm was most severe east and north of Phoenix. The total storm precipitation at Phoenix was 3.85 inches. Heaviest precipitation for the period was 13.55 inches at Crown King and 12.11 inches at Sunflower. About 65 percent of the total storm occurred during the maximum 24-hour period. The isohyets of the total storm precipitation are shown on plate 5.

(f) An estimate by the U.S. Soil Conservation Service based on high-water marks at numerous breaks in the Beardsley Canal in the Trilby Wash area (about 25 miles northwest of Phoenix) indicated a total nonsynchronized flow of about 34,000 cubic feet per second. The volume was estimated at 10,600 acre-feet. The peak discharge at Luke Air Force Base was estimated at 5,000 cubic feet per second by the U.S. Geological Survey. No flood estimates are available for the study area.

(g) Storm and flood of August 19, 1954.--Very moist, warm, tropical air that originated over the Gulf of Mexico entered Arizona and New Mexico from the south during the storm period, accompanied by widespread thunderstorm activity. The storm and flood of August 19, 1954, were the most severe of record within the Queen Creek drainage area, approximately 50 miles east-southeast of Phoenix. Precipitation in the area occurred between 0100 and about 0900 hours on the morning of August 19 in the Superstition Mountains and Pinal Mountains areas. The precipitation intensities were high during the first 3 hours of the storm. Light precipitation prevailed generally for another 3 hours. The Boyce Thompson South Western Arboretum, about 4 miles west of Superior, reported the highest precipitation amount of 5.3 inches (most of it falling within 3 hours). Florence Junction, about 15 miles west of Superior, reported 1- and 6-hour amounts of 1.8 and 4.2 inches, respectively. An estimated 100 square miles

of area had over 5 inches of precipitation, and approximately 1,000 square miles had over 1 inch of precipitation. The isohyets of total-storm precipitation are shown on plate 6.

(h) Peak discharge at the gaging station on Queen Creek at Whitlow Ranch damsite near Superior, Ariz., (drainage area, 143 square miles) was estimated at 42,900 cubic feet per second. No estimate of runoff is available for the study area.

(i) Storm and flood of September 25-26, 1962.--The unusually heavy precipitation during the storm was associated with a tropical storm originating off the west coast of lower California. The main stream of moist air, which was about 70 miles wide, passed over Sells, the Tucson Mountains-Cortaro area, Oracle, and on into New Mexico. Heaviest rain fell during the night of September 25 and most of September 26. A total of 4 inches of precipitation occurred at Sells in a 10-hour period on September 25 and 26. Estimates of depths of 7 inches were made for two locations about 17 and 22 miles west of Tucson.

(j) Preliminary peak discharges were estimated by the U.S. Geological Survey for the Santa Rosa Wash, near Vaiva Vo, at 53,000 cubic feet per second, and for the Santa Rosa Wash, at State Highway No. 84 between Casa Grande and Stanfield, at 12,800 cubic feet per second. No estimate of runoff is available for the study area.

12. Relative magnitude of local storms.--The relative severity of past general storms and local storms in the Gila River basin was determined by analyzing precipitation area-depth duration relationships. The analysis in the study area showed that, although the total precipitation for general winter storms is greater, the short-time precipitation intensities for the local thunderstorms are more critical. The analyses indicated that the local thunderstorm would be the critical flood-producing storms for the study area. The relative magnitude of precipitation for recorded local storms is best shown by intensity-duration and depth-area curves (see pl. 7).

SYNTHESIS OF STANDARD PROJECT FLOOD

13. General.--The standard-project-flood discharges were developed according to criteria given in EM 1110-2-1411.

14. Determination of standard project storm.--The standard project storm for the areas above the selected concentration points was determined by evaluation of the most severe regional storm of record assumed to be critically centered over the pertinent area. Precipitation occurring as snow was not considered to be a factor during the standard project storm, because the most severe regional storms occur during the summer.

15. Standard project storm.--The August 19, 1954, thunderstorm that centered generally in the Queen Creek drainage area was determined to be the storm with the most critical precipitation factors that may reasonably be expected to occur over the drainage area. While the storm lasted about 6 hours, local observations during the storm indicated that most of the precipitation fell during a 3-hour period. The assumption was, therefore, made that the total precipitation amount would fall during a 3-hour period, and the standard project storm was developed accordingly. The further assumption was made that during the prior 3-hour period sufficient precipitation (say 0.5 to 1.0 inch) to condition the ground for runoff would occur. The methods used to determine the precipitation and the precipitation-intensity pattern are explained in the following subparagraphs.

(a) Precipitation.--Precipitation amounts were obtained from isohyets (see pl. 6) of the August 19, 1954, thunderstorm, transposed and centered over pertinent subareas. Depth-duration relationships for selected subareas are given in the following table as being representative of precipitation used for the development of the standard project flood.

Precipitation depths during the standard project storm for drainage areas above the recommended detention basins, Phoenix, Ariz., and vicinity (including New River)

Detention basin*	Drainage area	Average depth of precipitation over the various areas for indicated duration		
		Maximum ½-hour	Maximum 1-hour	Maximum 3-hour
	Square miles	Inches	Inches	Inches
New River	170.0	1.6	3.1	4.7
Adobe	82.5	1.8	3.4	5.1
Cave Buttes	193.0	1.6	3.1	4.7
Dreamy Draw	1.3	1.8	3.4	5.2

* See pl. 2 for location.

(b) Precipitation-intensity pattern.--The time distribution of precipitation used for this study was based on the average precipitation-intensity pattern for 13 severe thunderstorms that occurred in Arizona. These storms had adequate intensity data and varied in length from 3/4 to 3-1/2 hours. Time intervals of 15 minutes, 30 minutes, and 1 hour (depending on the size of the area) were selected as the shortest time intervals for which precipitation intensities would be required to define the peak discharges. A typical precipitation-intensity pattern is shown on plate 8.

16. Precipitation-runoff relationships.--Available precipitation and runoff records are inadequate for an analysis of precipitation-runoff relationships in the drainage area. The precipitation-runoff relationships that were adopted for this study were based on information from hydrologic investigations made for other flood-control reports for comparable streams in southwestern United States. Elements used to establish the precipitation-runoff relationships are explained in the following subparagraphs.

(a) Unit hydrographs.--The method used to develop unit hydrographs is explained in paragraphs 70 to 75, inclusive, of the district engineer's report titled "Hydrology, San Gabriel River and the Rio Hondo Above Whittier Narrows Flood-Control Basin with Addendum on the Hydrologic Effect of Diverting Outflow from Whittier Narrows Flood-Control Basin to Los Angeles River Via the Rio Hondo," dated December 20, 1944, and revised July 10, 1946.* The synthetic unit-hydrographs used for the various subareas were developed from use of the lag-relationships curve (pl. 9) and S-graphs (pl. 10) developed from studies of areas in southern California and the Gila River basin. The S-graph used for the valley areas was developed to apply to regional drainage areas of less than 1,500 square miles in the Gila River basin. The S-graph used for the mountain areas was developed for the mountain areas of southern California.

(b) Precipitation-loss rates.--The selection of precipitation-loss rates for the drainage area was based on precipitation-loss-rate studies for areas in southwestern United States. As previously stated, a prior 3-hour precipitation was assumed to have satisfied the expected initial loss. For the mountain areas, a variable-loss rate was assumed for the critical 3-hour period, ranging from 0.65 to 0.20 inch per hour, with an average loss rate of 0.35 inch per hour. The loss rate in the valley area (0.20 inch per hour) was assumed constant during the standard project storm. On the basis of previous studies of probable population increase and resulting urban development during the next 100 years, it was assumed that the area below the Union Hills diversion channel would become improved and that 25 percent of the improved valley area would become all-impervious. Therefore, in development of the standard project flood for each concentration point, 25 percent of the assumed improved area of each valley subarea was considered all-impervious and the amounts of effective precipitation (total precipitation minus precipitation loss) were computed accordingly.

(c) Base flow and channel percolation.--Base flow and channel percolation were assumed negligible during the standard project flood.

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* Report was approved by the Office, Chief of Engineers in 2d indorsement dated May 12, 1945, and 6th indorsement dated October 1, 1946, to basic letter dated January 30, 1945, subject: "Hydrology, Whittier Narrows Flood-Control Basin, Los Angeles County Drainage Area, California."

17. Determination of standard project flood.--The standard project flood was determined at each of the selected concentration points by the following procedure: (a) determination of unit-time increments of precipitation for each subarea; (b) determination of effective precipitation by subtraction of loss rate and application of the imperviousness factor where applicable; (c) determination of subarea surface-runoff hydrograph by application of subarea synthetic unit-hydrograph values to the effective unit-period precipitation; and (d) determination of total flood hydrograph for the concentration points by channel routing, reservoir routing, and combining subarea hydrographs as required. Because of the estimated rate of sediment inflow during the life of the considered flood-control improvements, the existing Cave Creek flood-control dam is assumed to be full of sediment and to have negligible control. There would be negligible flow from the areas above Lake Pleasant Dam and McMicken Dam during the standard project flood on the Agua Fria River at the Gila River, as the standard project flood resulted from a storm centered below these dams. The existing canals have negligible effect during the standard project flood. The outlets at the recommended Adobe, New River, Cave Buttes, and Dreamy Draw detention basins are assumed to be operative. The recommended diversion channels are assumed to divert their total capacities (including freeboard) to Skunk Creek. The total capacity of Union Hills diversion channel west of Cave Creek and at Skunk Creek is 18,300 and 19,600 cubic feet per second, respectively. The total capacity of Arizona Canal diversion channel west of Cave Creek and at Skunk Creek is 18,500 and 28,500 cubic feet per second, respectively.

18. The routing of the floods to and through the recommended diversion channels was accomplished by the successive average-lag method that is described in EM 1110-2-1408. The routing of floods through the reservoirs was performed by the Puls I.S.D. method, which is described in the report titled "Engineering Construction, Flood Control," dated 1940, and published by the Engineering School, Fort Belvoir, Va.

19. Standard project flood.--Standard-project-flood peak discharges for selected concentration points are shown on plate 11, and the hydrographs with pertinent data for each detention basin are shown on plates 8, 12, 13, and 14. The design peak discharges as determined by economic studies and other considerations and given in main report are shown on plate 11.

SYNTHESIS OF MAXIMUM PROBABLE FLOOD

20. General.--The maximum probable flood is defined as the flood that would result if the probable maximum precipitation for the drainage areas were to occur at a time when ground conditions were conducive to maximum runoff. Such a flood is required in developing plans for the recommended detention dams.

21. Determination of probable maximum storm.--Because the method used by the U.S. Weather Bureau in determining the probable maximum storm for small areas is subject to more study, a method that was developed by the U.S. Army Engineer District, Los Angeles, and that was based on a method in an early report of the U.S. Weather Bureau was used in making estimates of probable maximum precipitation. Both methods are described in Design Memorandum No. 1, "Hydrology for Wilson Canyon and Mansfield Street Channels and Debris Basins," dated May 1959.* The probable maximum precipitation and the precipitation-intensity pattern developed from the Los Angeles District's method are described in the following subparagraphs.

(a) Probable maximum precipitation.--The probable maximum precipitation depth and duration for the drainage areas above the recommended detention basins during the probable maximum storm is given in the following table:

Precipitation depths during the maximum probable storm for drainage areas above the recommended detention basins, Phoenix, Ariz., and vicinity (including New River)

Detention basin*	Drainage area	Average depth of precipitation over the various areas for indicated duration			
		Maximum ½-hour	Maximum 1-hour	Maximum 3-hour	Maximum 6-hour
	Square miles	Inches	Inches	Inches	Inches
New River	170.0	2.0	3.8	8.6	10.5
Adobe	82.5	2.6	4.8	10.3	12.5
Cave Buttes	193.0	1.7	3.3	7.6	9.2
Dreamy Draw	1.3	6.4	9.5	17.2	19.6

* See pl 2 for location.

(b) Precipitation-intensity pattern.--Time intervals of 15 minutes, 30 minutes, and 1 hour (depending on size of the area) were selected as the shortest time interval required to adequately define the flood peaks. Rainfall intensities were obtained from

* This design memorandum was approved by the Office, Chief of Engineers October 8, 1959, and will hereinafter be referred to as the Wilson-Mansfield report.

a curve of depth-duration relationships (curve II, pl. 10, Wilson-Mansfield report) and arranged in order of time with regard to maximum values of the unit hydrograph, so that maximum peak discharges were obtained. A typical precipitation-intensity pattern is shown on plate 15.

22. Precipitation-runoff relationships.--The precipitation-runoff relationships as applied to the maximum probable floods were determined in a manner similar to that described herein for the standard project floods, except for precipitation-loss rates. Ground conditions conducive to maximum runoff are reflected in the minimum precipitation-loss rates indicated in unit-hydrograph studies for similar areas. On the basis of these studies, a minimum loss rate of 0.15 inch per hour was considered applicable to the drainage area and was assumed to prevail at a constant rate throughout the probable maximum storm.

23. Determination of maximum probable flood.--The computation of maximum probable floods for the recommended detention basins was similar to that of the standard project floods.

24. Maximum-probable flood.--The maximum-probable-flood hydrographs with pertinent data for each detention basin are shown on plates 15, 16, 17, and 18.

SEDIMENT STORAGE

25. General.--An estimate of the volume of storage space behind the recommended detention basins that will be occupied by sediment at the end of a 100-year period is required for the design of the detention dams.

26. Topographical, geological, and hydrometeorological characteristics of the drainage area upstream from the recommended detention basins indicate a moderate sediment-production potential. The streambed profiles upstream of the recommended detention basins indicate a moderate sediment-production potential. The streambed profiles upstream of the recommended detention basins are shown on plate 3.

27. Sediment-storage estimate.--The method applied in this study to determine the sediment storage for the recommended detention basins on New River, Skunk Creek, and Cave Creek is based on the rate of sediment produced by the average annual runoff. In determining the sediment storage for Cave Buttes detention basin, the assumption was made that the existing Cave Creek Dam would control the sediment from that drainage area (162 sq. miles). Data for other streams in the general area, including the Agua Fria River at Lake Pleasant, were used as the basis for the estimated average annual runoff at the detention basins. The inflow-sediment relationship is based on observed sedimentation data for conservation reservoirs in southwestern United States as given in

table 2 and shown on plate 19. The estimated rate of sediment production at Lake Pleasant and Cave Creek Dams is 0.56 and 0.74 acre-feet per square mile per year, respectively. For small drainage areas in southern California, the sediment rate was estimated to be 1 acre-foot per square mile per year. The sediment storage for the recommended Dreamy Draw detention basin is based on the sediment rate of approximately 1 acre-foot per square mile per year. The estimated average annual inflow and sediment-storage requirements for a 100-year period for the recommended detention basins are given in the following table:

Estimated sediment-storage requirements for the recommended detention basins, Phoenix, Ariz., and vicinity (including New River)

Name*	Drainage area	Estimated average annual inflow	Sediment storage
	Square miles	Acre-feet per square mile	Acre-feet
New River detention basin.....	170.0	48	10,000
Adobe detention basin.....	82.5	60	5,500
Cave Buttes detention basin.....	**31.4	83	2,500
Dreamy Draw detention basin.....	1.3	(***)	150

* See pl. 2 for location.
** Excluding area above Cave Creek Dam.
*** Not estimated. Sediment storage estimated on sediment rate of approximately 1 acre-foot per square mile per year.

ADEQUACY OF FLOODS AND SEDIMENT STORAGE

28. Standard project flood.--The standard project flood as developed is of a magnitude that would be exceeded only on rare occasions. Because of lack of streamflow records, the adequacy of the standard project flood is best appraised from the magnitude of the factors used in its synthesis. The use of the August 19, 1954, storm transposed to produce the most critical precipitation over the drainage area, as well as the use of a more intense precipitation pattern and comparatively low loss rates, represent a reasonably severe combination of factors.

29. The adequacy of the standard-project-flood peak discharges is further indicated by comparison of those discharges with enveloping curves of peak discharges shown on plate 20.

30. Maximum probable flood.--The adequacy of the maximum probable flood for the recommended detention basins is best indicated by the severity of the various hydrologic factors (storm magnitude,

precipitation-intensity pattern, and loss rate) on which the flood estimate is based. The occurrence of any of these factors in the severity assumed would be infrequent, and obviously a flood resulting from the combination of all of these conditions would be very severe. An indication of the adequacy of the maximum-probable-flood peak discharges is shown by the relatively high plotting position of the points representing the maximum-probable-flood peak discharges on the enveloping curves of peak discharges shown on plate 20. A further indication of the adequacy of the maximum-probable-flood peak discharges is the fact that they are from 2 to 5 times the standard-project-flood peak discharges.

31. Sediment storage.--The 100-year sediment storage as developed is considered conservative for the recommended detention basins.

PRIOR APPROVAL

32. The standard project and maximum probable floods and the sediment-storage requirements presented in a draft of this appendix were approved by the office of the Chief of Engineers in 2d indorsement dated October 2, 1963, to basic letter dated June 13, 1963, subject: "Interim Report on Survey for Flood Control, Phoenix, Ariz., and Vicinity (Including New River), Gila River Basin, Ariz."

Table 1

Precipitation stations in and near Phoenix, Ariz., and vicinity (including New River)

Number*	Station**	Elevation	Geographic coordinates		Period of record		Complete years of record	Computed 90-year mean-annual precipitation
			Latitude	Longitude	Recording gage	Non-recording gage		
		Feet	Degrees and minutes	Degrees and minutes				Inches
13-0-3...	Prescott Dry Farm.....	5,008	34-37	112-24	.....	1912-29	14	12.99
13-0-7...	Prescott W. B. Airport.	5,014	34-39	112-26	1942-62	1942-62	20	12.76
13-0-8B..	Yaeger Canyon.....	6,000	34-41	112-10	.....	1917-62	24	17.04
13-0-11..	Willow Creek Ranger Station.	5,550	34-36	112-31	.....	1912-19	.....	.....
13-0-12..	Prescott.....	5,410	34-33	112-27	1939-42	1866-1962	96	18.40
13-0-14..	Groom Creek.....	6,100	34-29	112-27	.....	1942-62	16	24.59
13-0-18..	Walnut Grove.....	3,764	34-18	112-33	.....	1889-1962	61	15.94
13-0-19..	Cordes.....	3,773	34-18	112-10	.....	1925-62	36	12.14
13-0-21..	Crown King.....	6,000	34-12	112-20	.....	1914-62	35	24.98
13-0-26..	Constellation.....	3,600	34-04	112-34	.....	1921-35	5	13.88
13-0-27..	Canon.....	1,990	34-04	112-09	.....	1915-29	8	14.13
13-0-28..	Champie Camp.....	2,300	34-01	112-21	.....	1898-1914	11	15.30
13-0-29..	Poland Junction.....	4,900	34-27	112-16	1942-62	.....	20	14.00
13-0-32..	Chino Valley.....	4,750	34-45	112-28	.....	1941-62	21	12.58
13-0-40..	Castle Hot Springs.....	2,800	34-03	112-21	.....	1889-1962	18	15.36

See footnotes at end of table.

Table 1--Continued

Precipitation stations in and near Phoenix, Ariz., and vicinity (including New River)--Continued

Number*	Station**	Elevation	Geographic coordinates		Period of record		Complete years of record	Computed 90-year mean-annual precipitation
			Latitude	Longitude	Recording gage	Non-recording gage		
		Feet	Degrees and minutes	Degrees and minutes				Inches
13-P-1...	Wickenburg.....	2,070	33-58	112-44	.....	1877-1962	56	10.77
13-P-4...	Marinette.....	1,145	33-36	112-18	.....	1890-1962	36	8.05
13-P-6...	Litchfield Park.....	1,030	33-30	112-22	.....	1917-62	45	8.18
13-P-7...	Phoenix Indian School..	1,115	33-30	112-04	.....	1920-62	23	7.34
13-P-8...	Phoenix Nursery (Phoenix 2).	1,189	33-31	112-03	.....	1905-15	3	.....
13-P-9...	Phoenix Post Office....	1,083	33-27	112-04	1901-62	1876-1962	86	7.53
13-P-10..	Phoenix W. B. Airport..	1,109	33-26	112-01	1953-62	1933-62	22	7.31
13-P-13..	South Phoenix.....	1,195	33-23	112-04	.....	1915-62	40	7.33
13-P-14..	Buckeye.....	888	33-23	112-35	.....	1891-1962	62	7.53
13-P-18..	Wittman.....	1,540	33-46	112-31	.....	1923-62	27	9.45
13-P-31..	Alhambra 2 NE.....	1,135	33-31	112-07	.....	1946-62	19	7.53
13-P-33..	Lake Pleasant.....	1,600	33-51	112-16	.....	1949-62	13	9.10
13-P-34..	Beardsley.....	1,265	33-40	112-23	.....	1950-62	13	8.42
13-P-35..	Griggs 3 W.....	1,160	33-30	112-29	.....	1950-62	13	6.73
13-P-36..	Cave Creek Dam.....	1,630	33-43	112-03	.....	1950-62	12	9.65

See footnotes at end of table.

Table 1--Continued

Precipitation stations in and near Phoenix, Ariz., and vicinity (including New River)--Continued

Number*	Station**	Elevation	Geographic coordinates		Period of record		Complete years of record	Computed 90-year mean-annual precipitation
			Latitude	Longitude	Recording gage	Non-recording gage		
		Feet	Degrees and minutes	Degrees and minutes				Inches
13-P-37..	Deer Valley.....	1,245	33-35	112-09	.....	1950-62	11	8.37
13-P-46..	Laveen.....	1,110	33-20	112-09	.....	1948-62	14	7.66
13-P-47..	Tolleson 2 NW.....	1,000	33-28	112-16	.....	1951-62	11	7.53
13-P-48..	Sunnyslope.....	1,316	33-34	112-04	.....	1948-62	.....	.....
14-0-10..	Camp Verde.....	3,160	34-35	111-51	.....	1867-90	21	11.95
14-0-14..	Dugos 2 SE.....	4,000	34-21	111-57	.....	1919-62	33	16.34
14-0-15..	Childs.....	2,650	34-21	111-42	.....	1915-62	40	16.59
14-P-1...	Ashdale R. S.....	3,300	33-58	111-53	.....	1915-48	18	21.29
14-P-8...	Paradise Valley.....	1,421	33-33	111-58	.....	1955-62	7	.....
14-P-11..	Cave Creek.....	2,150	33-50	111-57	.....	1907-61	12	11.49
14-P-14..	Granite Reef Dam.....	1,325	33-31	111-42	.....	1889-1962	74	9.60
14-P-16..	Wilbur Ranch.....	1,375	33-27	111-43	.....	1924-28	4	.....
14-P-18..	Mesa Experiment Farm.	1,225	33-25	111-52	.....	1896-1962	66	8.03
14-P-21..	Chandler.....	1,212	33-18	111-50	.....	1912-62	32	7.84
14-P-26..	Goodyear.....	1,203	33-25	111-52	.....	1918-33	12	8.44

See footnotes at end of table.

Table 1--Continued

Precipitation stations in and near Phoenix, Ariz., and vicinity (including New River)--Continued

Number*	Station**	Elevation	Geographic coordinates		Period of record		Complete years of record	Computed 90-year mean-annual precipitation
			Latitude	Longitude	Recording gage	Non-recording gage		
		Feet	Degrees and minutes	Degrees and minutes				Inches
14-P-34..	Stewart Mountain.....	1,422	33-34	111-32	.....	1939-62	22	11.77
14-P-35..	Tempe No. 2.....	1,159	33-26	111-56	.....	1889-1962	36	7.58
14-P-45..	Bartlett Dam.....	1,650	33-49	111-38	.....	1939-62	23	11.71
14-P-47..	Falcon Field.....	1,320	33-26	111-45	.....	1942-62	15	8.23
14-P-49..	Tempe U. of A. Citrus Exp. Sta.	1,180	33-25	111-58	.....	1943-62	16	7.74
14-P-60..	Camelback.....	1,250	33-29	111-58	.....	1920-62	31	7.80
14-P-61..	Horseshoe Dam.....	2,020	33-59	111-43	.....	1948-62	13	14.26
14-P-65..	Carefree.....	2,530	33-49	111-54	.....	1961-62	.....	.....

* Stations numbered in accordance with quadrangle-index system of the U.S. Army Engineer District, Los Angeles, Corps of Engineers.

** See pl. 1 for location.

NOTE.--Above data, except station number and 90-year (1868-1957) mean-annual precipitation, obtained from publications of the U.S. Weather Bureau.

Table 2

Pertinent data on observed sedimentation, conservation reservoirs in southwestern United States, Phoenix, Ariz., and vicinity (including New River)

No.	Reservoir		Contributing drainage area	Period of record	Years of record	Total inflow for period of record		Inflow per square mile of drainage area per year	
	Name	Location				Water	Sediment	Water	Sediment
			Sq. mile			Acre-ft.	Acre-ft.	Acre-ft.	Acre-ft.
1	San Carlos	Arizona	11,900	1928-47	18.2	4,640,600	57,494	*21.4	*0.266
2	Lake Pleasant	do	1,444	1928-41	12.9	(**)	8,044	(**)	(**)
3	do	do	5,760	1909-46	36.8	29,186,000	140,600	137.7	.663
4	Conchas	New Mexico	6,950	1939-49	10.1	2,706,000	35,600	38.2	.506
5	Elephant Butte	do	25,866	1915-47	32.3	34,807,000	465,000	41.7	.556
6	Lake Mead	Nevada-Arizona	167,600	1935-48	13.7	181,296,000	1,425,000	79.0	.620
7	Lake Hodges	California	301	1919-48	29.5	1,139,000	3,323	128.3	.375
8	San Dimas	do	16	1922-44	22.1	50,200	488	141.0	1.370
9	Sweetwater	do	181	1886-1927	39.0	740,000	6,170	105.0	.870
10	Gibralter	do	220	1920-31	11.0	206,000	2,100	85.1	.870

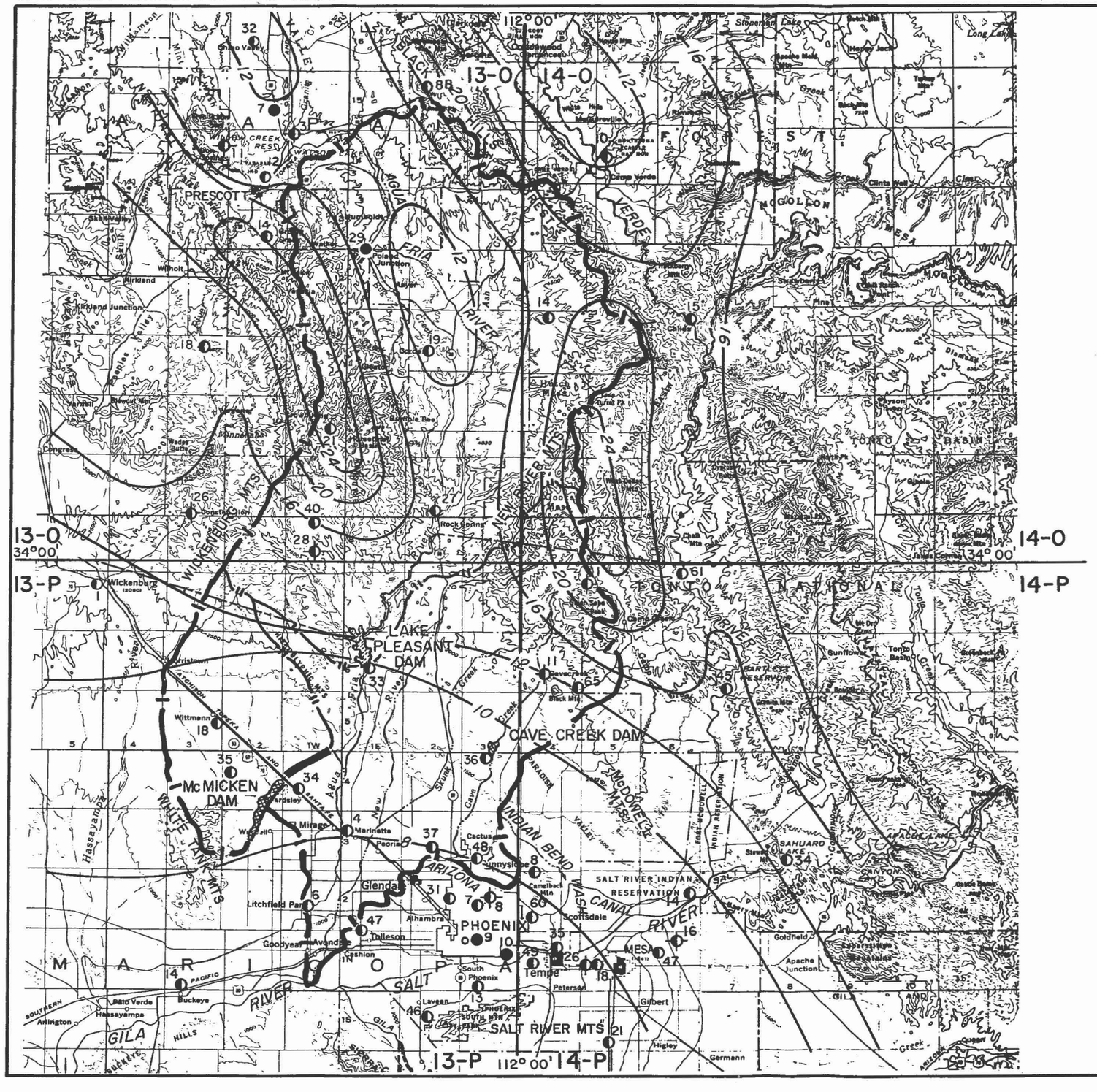
* The U.S. Bureau of Reclamation recommends that the following longtime average annual values be used for San Carlos Reservoir: 346,700 acre-feet for water inflow and 5,000 acre-feet for sediment inflow. By applying these values, the average-annual rate of inflow per square mile of drainage area becomes 29.1 acre-feet for water and 0.42 acre-feet for sediment.

** No complete record is available of total water inflow into Lake Pleasant for period of observed sediment inflow. On the basis of records for the Verde River (a nearby stream), estimates of total water inflow for period of sediment observation and of longtime rate of water inflow and sediment inflow indicate that for Lake Pleasant the average annual rate of inflow per square mile of drainage area would be 42.5 acre-feet for water and 0.56 acre-feet for sediment.

Note.--See curve on fig. 19.

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



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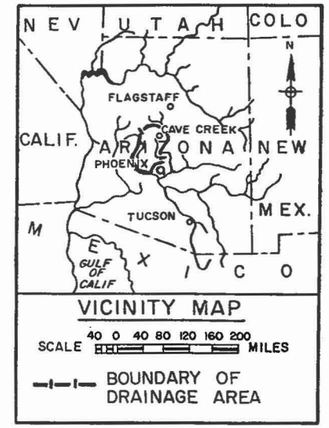


VICINITY MAP

SCALE 40 0 40 80 120 160 200 MILES

—I—I— BOUNDARY OF DRAINAGE AREA

LEGEND

—I— BOUNDARY OF DRAINAGE AREA

—II— BOUNDARY OF DRAINAGE SUBAREA

—10— LINE OF EQUAL PRECIPITATION IN INCHES. 90-YEAR (1868-1957) MEAN ANNUAL PRECIPITATION

EXISTING FLOOD CONTROL RESERVOIR

EXISTING WATER-CONSERVATION RESERVOIR

EXISTING CHANNEL

●9 PRECIPITATION STATION AND NUMBER (RECORDING)

◐7 PRECIPITATION STATION AND NUMBER (NON-RECORDING)

-⊕-8 PRECIPITATION STATION AND NUMBER. (NON-RECORDING, DISCONTINUED).

NOTE: MAP REPRODUCED FROM STATE OF ARIZONA MAP, SCALE 1:500,000

CONTOUR INTERVAL - 500 FEET

10 0 10 20

SCALE IN MILES

GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

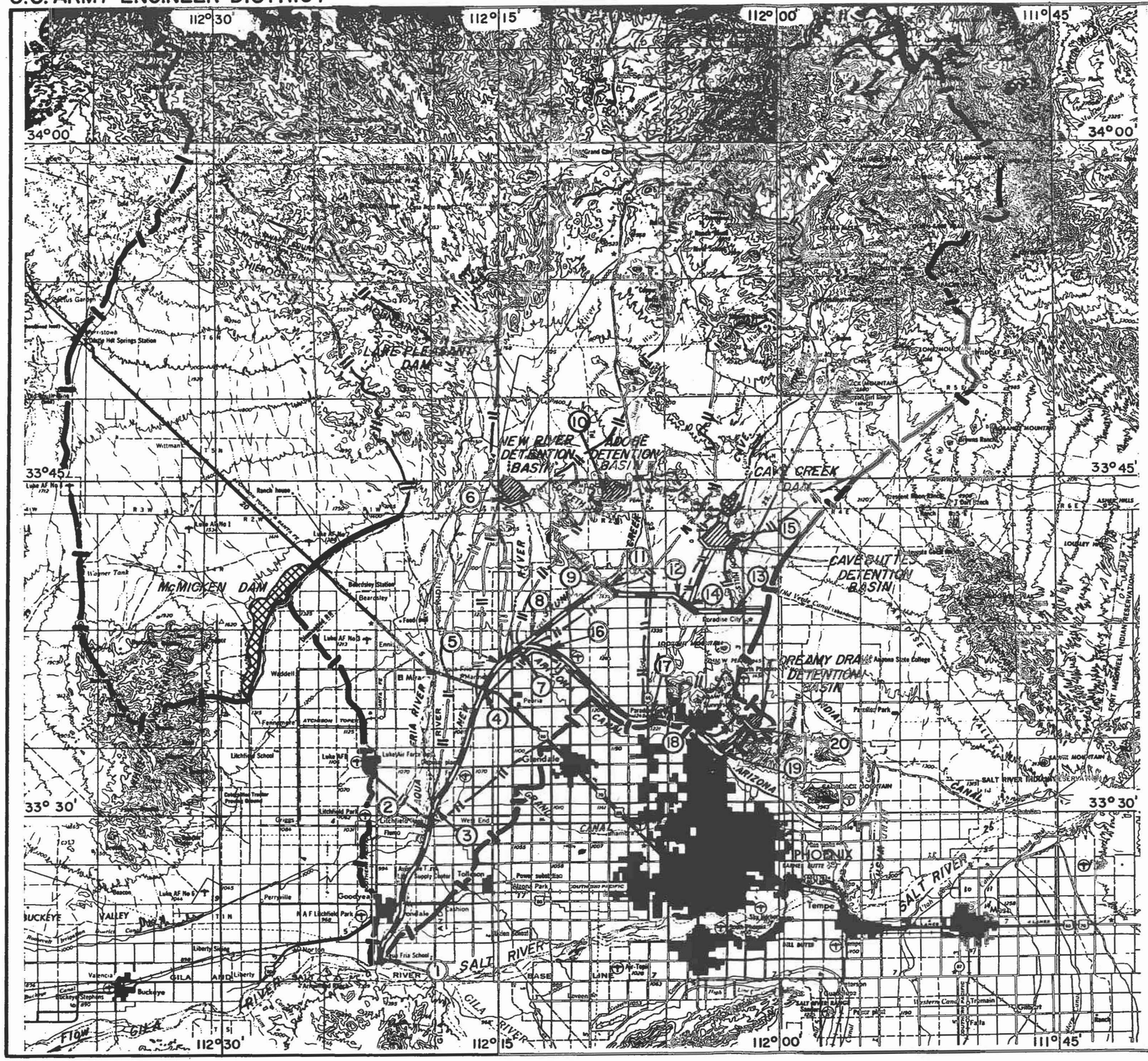
HYDROLOGIC MAP

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/99 APPENDIX I PLATE 1

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



LEGEND

- BOUNDARY OF DRAINAGE AREA
- BOUNDARY OF DRAINAGE SUBAREA
- RECOMMENDED DETENTION BASIN
- RECOMMENDED CHANNEL
- EXISTING CHANNEL
- EXISTING FLOOD-CONTROL RESERVOIR
- EXISTING WATER-CONSERVATION RESERVOIR
- (1) POINT OF CONCENTRATION

NOTE:

MAP REPRODUCED FROM U.S.G.S. QUADS, MESA, PHOENIX, PRESCOTT AND HOLBROOK 1:250,000 SCALE.

CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL.

5 0 5 10

SCALE IN MILES

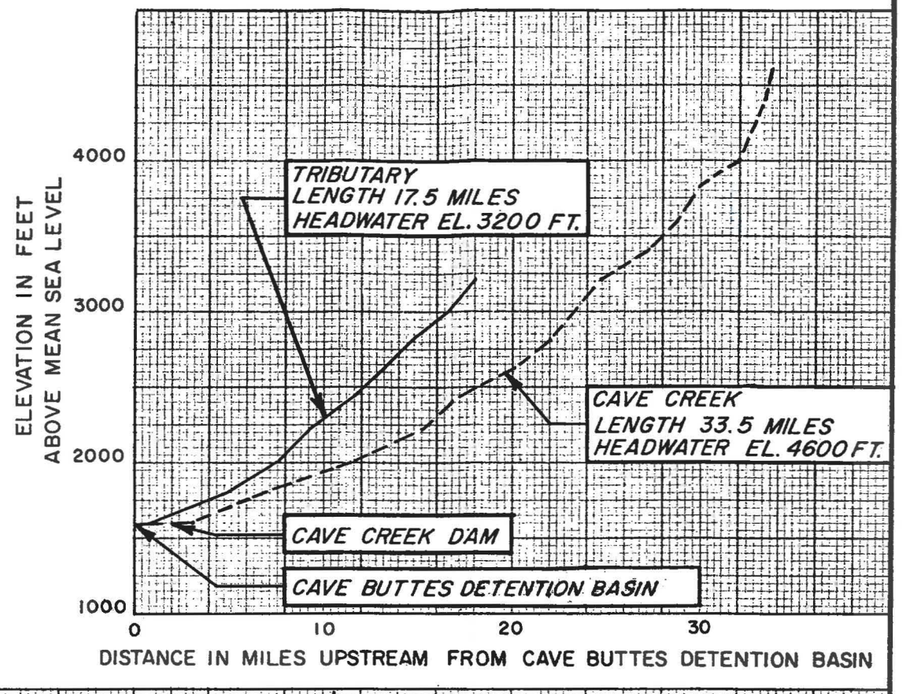
GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

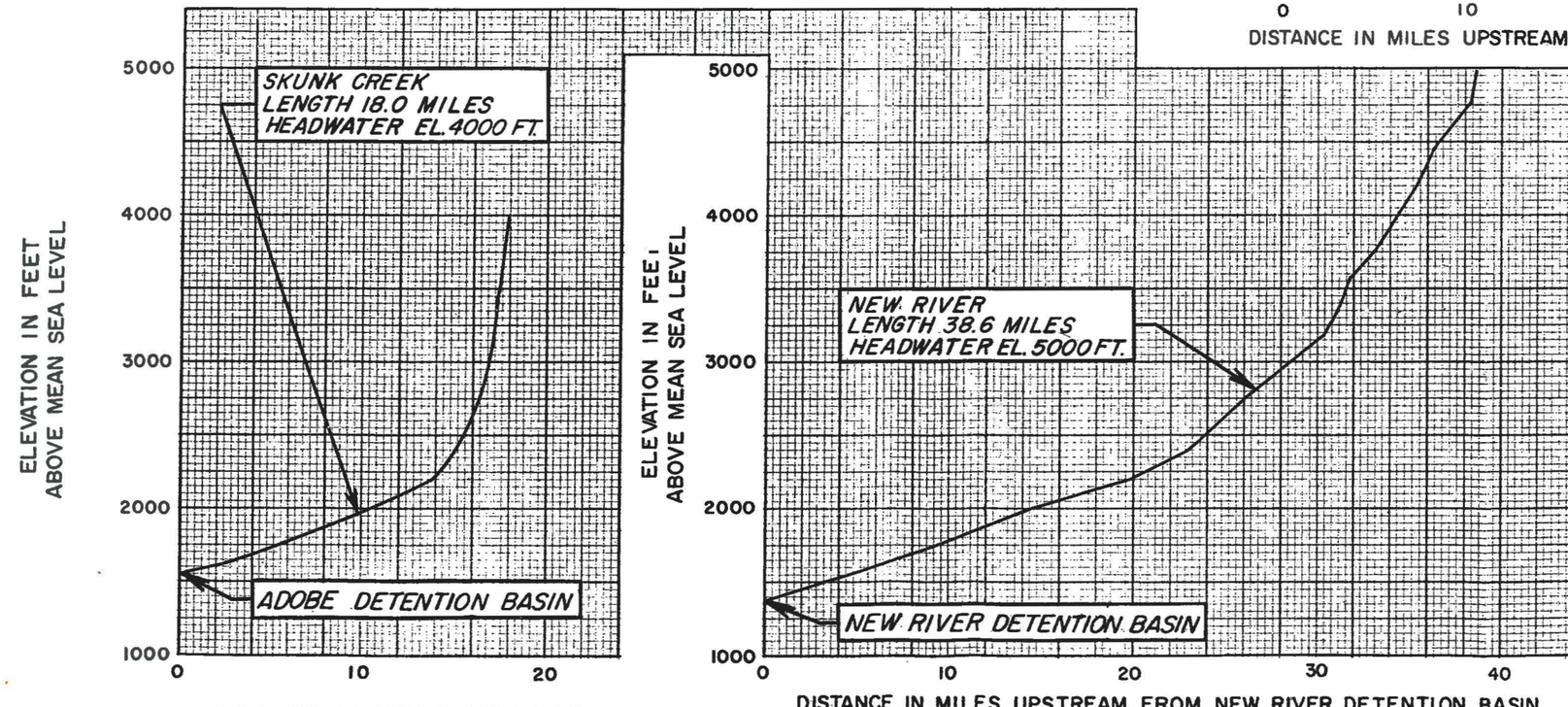
TOPOGRAPHY AND DRAINAGE AREA MAP

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/100 APPENDIX I PLATE 2

NOTE: THERE IS NOT ENOUGH TOPOGRAPHICAL DATA FOR THE DREAMY DRAW DRAINAGE AREA TO DETERMINE A STREAM BED PROFILE. THE ESTIMATED GRADIENT OF THE STREAM UP-STREAM OF DREAMY DRAW DETENTION BASIN IS APPROXIMATELY 280 FEET PER MILE.





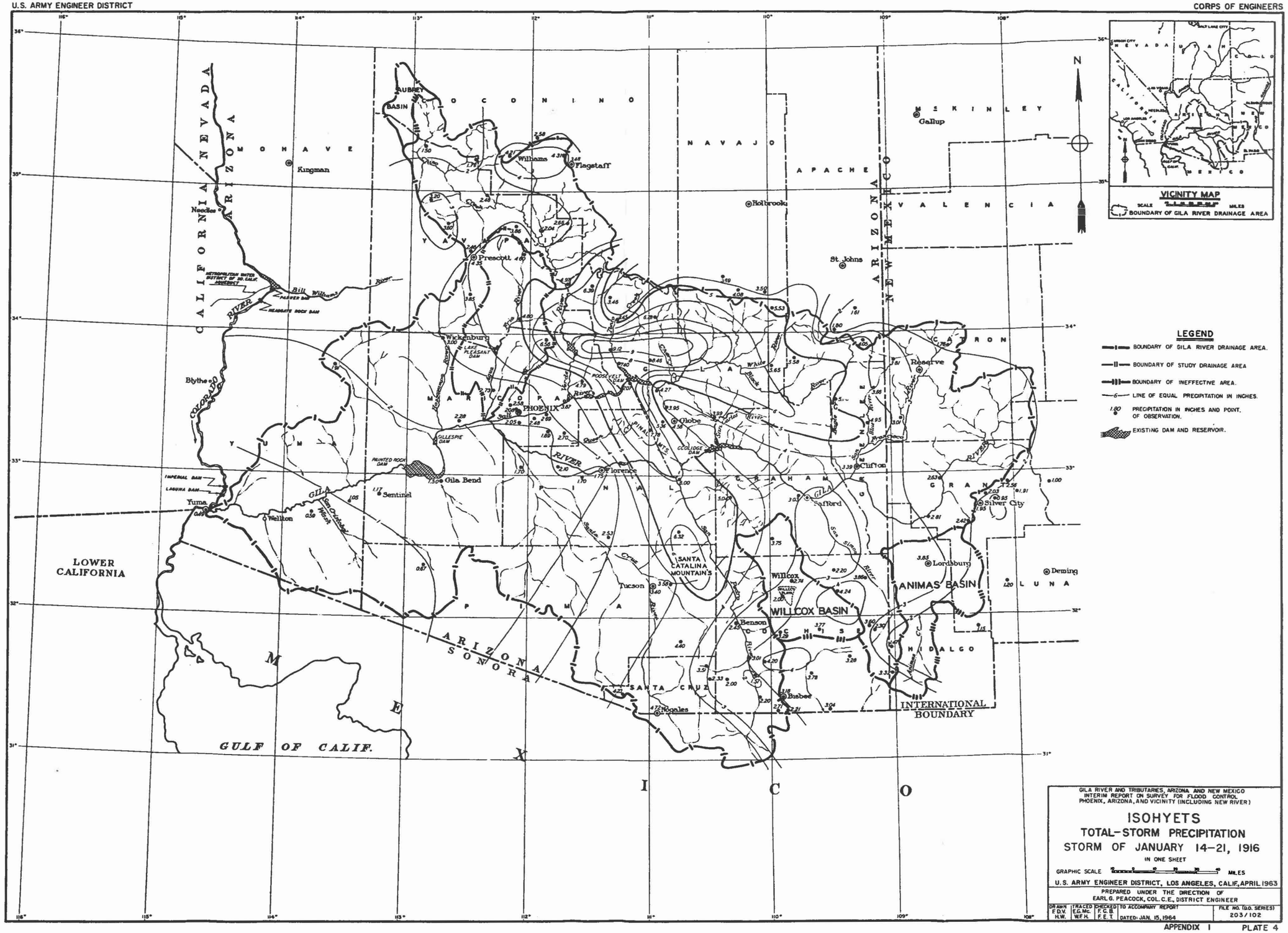
GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

STREAMBED PROFILES

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



VICINITY MAP

SCALE 0 100 200 300 400 MILES

BOUNDARY OF GILA RIVER DRAINAGE AREA

LEGEND

- BOUNDARY OF GILA RIVER DRAINAGE AREA.
- BOUNDARY OF STUDY DRAINAGE AREA
- BOUNDARY OF INEFFECTIVE AREA.
- 6 — LINE OF EQUAL PRECIPITATION IN INCHES.
- 1.80 PRECIPITATION IN INCHES AND POINT OF OBSERVATION.
- EXISTING DAM AND RESERVOIR.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA, AND VICINITY (INCLUDING NEW RIVER)

ISOHYETS
TOTAL-STORM PRECIPITATION
STORM OF JANUARY 14-21, 1916

IN ONE SHEET

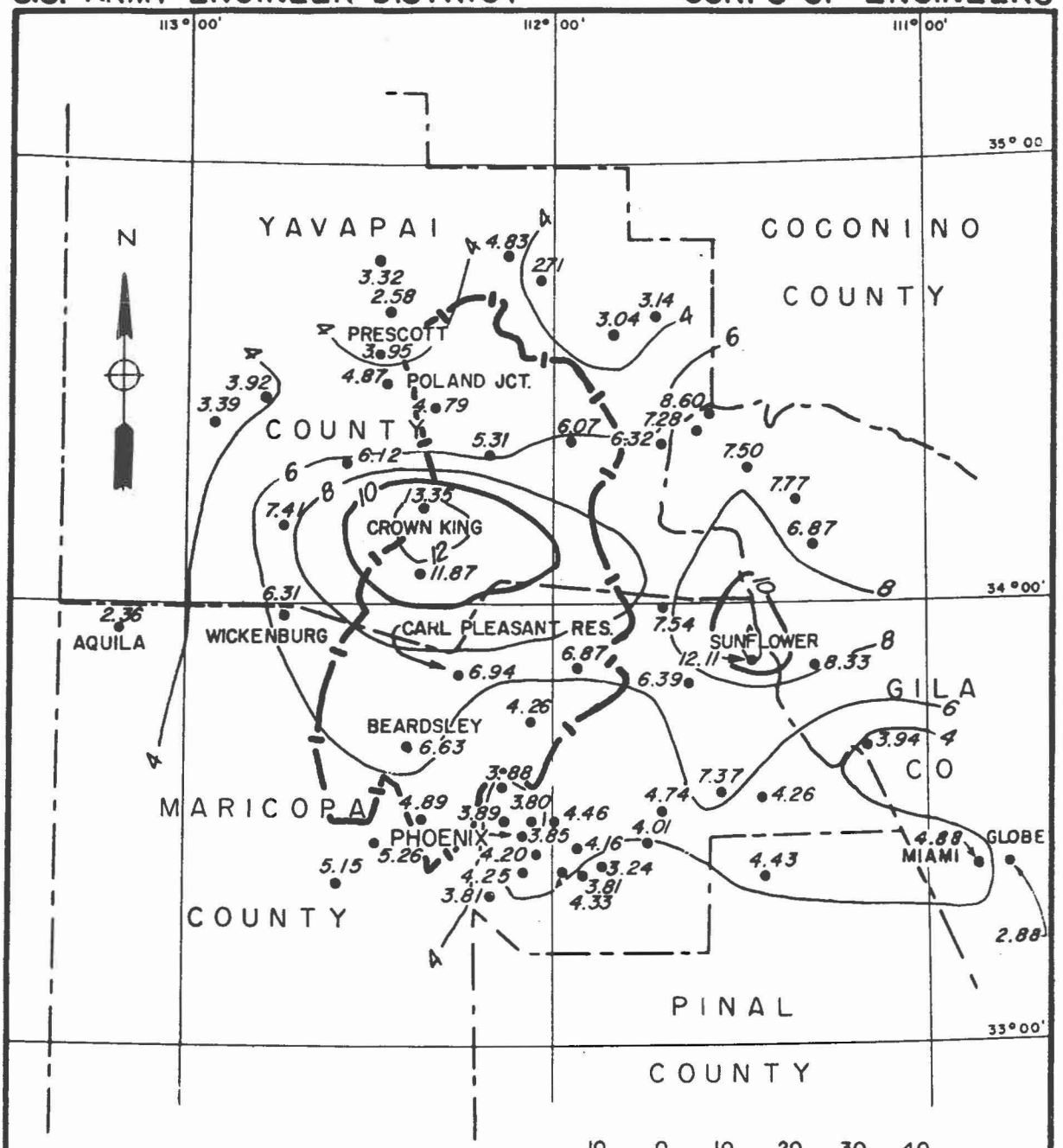
GRAPHIC SCALE 0 10 20 30 40 MILES

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF., APRIL 1963

PREPARED UNDER THE DIRECTION OF
EARL G. PEACOCK, COL. C.E., DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (O.O. SERIES)
F.D.V. H.W.	E.G.Mc. W.F.H.	F.C.B. F.E.T.	DATED: JAN. 15, 1964	203/102

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS



LEGEND

—1— BOUNDARY OF DRAINAGE AREA.
—8— LINE OF EQUAL PRECIPITATION IN INCHES.
● 6.31 RECORDED PRECIPITATION DEPTH IN INCHES.

GILA RIVER AND TRIBUTARIES, ARIZ, AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

ISOHYETS

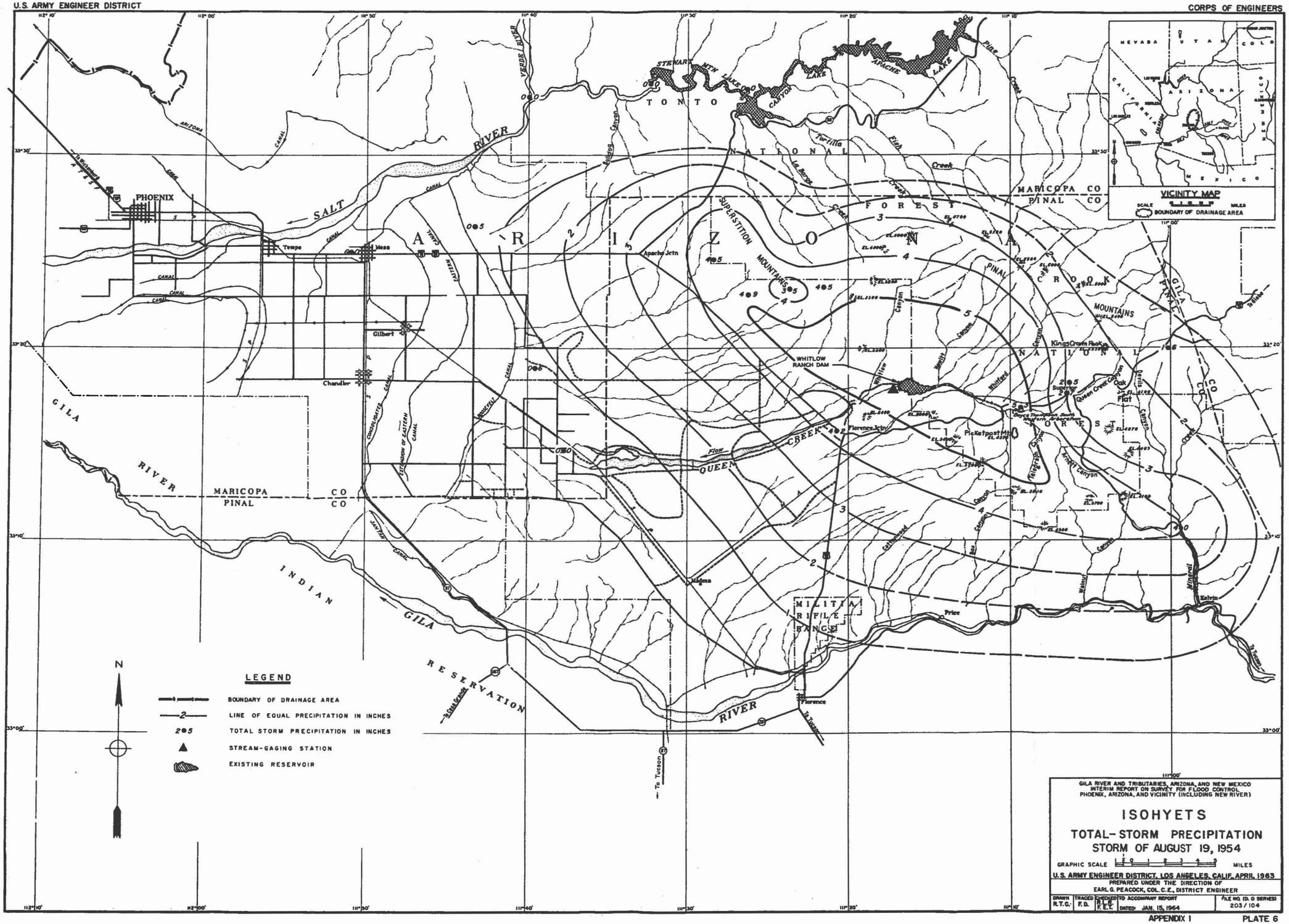
TOTAL-STORM PRECIPITATION
STORM OF AUGUST 26-29, 1951

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/103 APPENDIX I PLATE 5

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



GILA RIVER AND TRIBUTARIES, ARIZONA, AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA, AND VICINITY (INCLUDING NEW RIVER)

ISOHYETS

TOTAL-STORM PRECIPITATION
STORM OF AUGUST 19, 1954

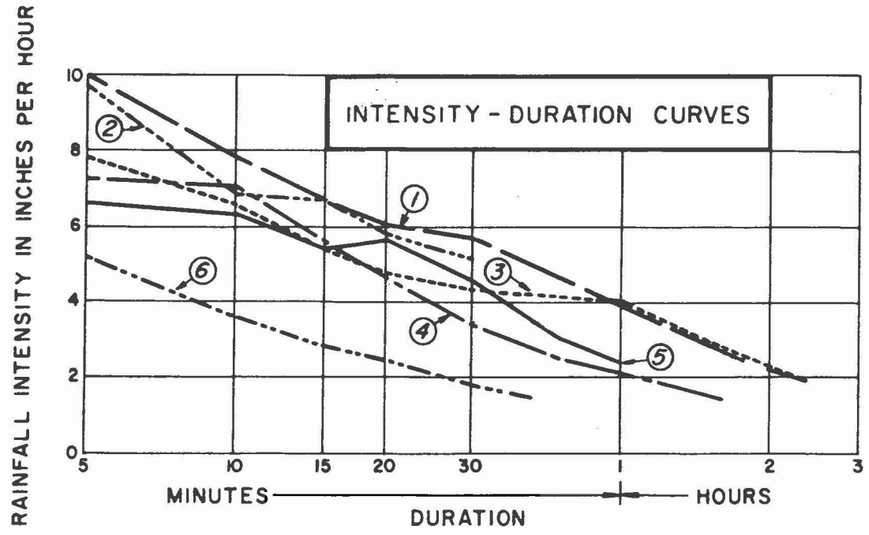
GRAPHIC SCALE 0 1 2 3 4 5 MILES

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF. APRIL 1963

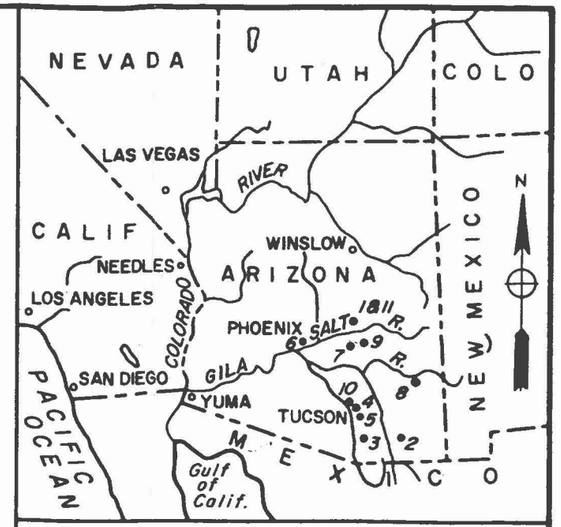
PREPARED UNDER THE DIRECTION OF
EARL G. PEACOCK, COL. C.E., DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	CHECKED	TO ACCOMPANY REPORT	FILE NO. ID. O SERIES
R.T.C.	F.D.	H.L.G.	F.E.T.	DATED: JAN. 15, 1964	203/104

APPENDIX I PLATE 6

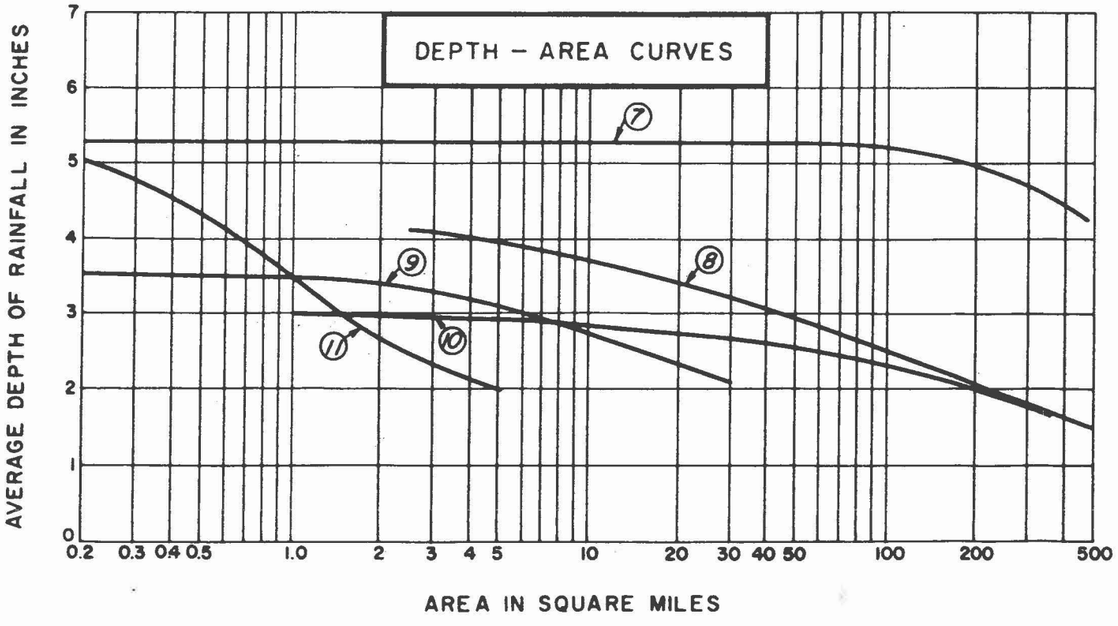


NOTE:
DATA FOR INTENSITY-DURATION CURVES ARE FOR STATIONS WITHIN THE STORM AREA BUT NOT NECESSARILY AT THE STORM CENTER.



VICINITY MAP

SCALE 40 0 40 80 120 MILES



CURVE NO.	STORM			
	LOCATION *	DATE	APPROXIMATE DURATION	
			HRS.	MIN.
1	PARKER CREEK	SEPT. 10, 1933	1	45
2	WALNUT GULCH	OCT. 4-5, 1954	0	30
3	SANTA RITA	JUNE 29, 1959	2	20
4	UNIV. OF ARIZONA	AUG. 13, 1940	1	35
5	TUCSON AIRPORT	SEPT. 24, 1943	1	0
6	PHOENIX	JULY 26, 1936	0	40
7	QUEEN CREEK	AUG. 19, 1954	6	0
8	THATCHER	SEPT. 16, 1939	1	30
9	GLOBE	JULY 29, 1954	1	0
10	TUCSON	SEPT. 24, 1943	3	0
11	PARKER CREEK	AUG. 5, 1939	2	20

* SEE VICINITY MAP

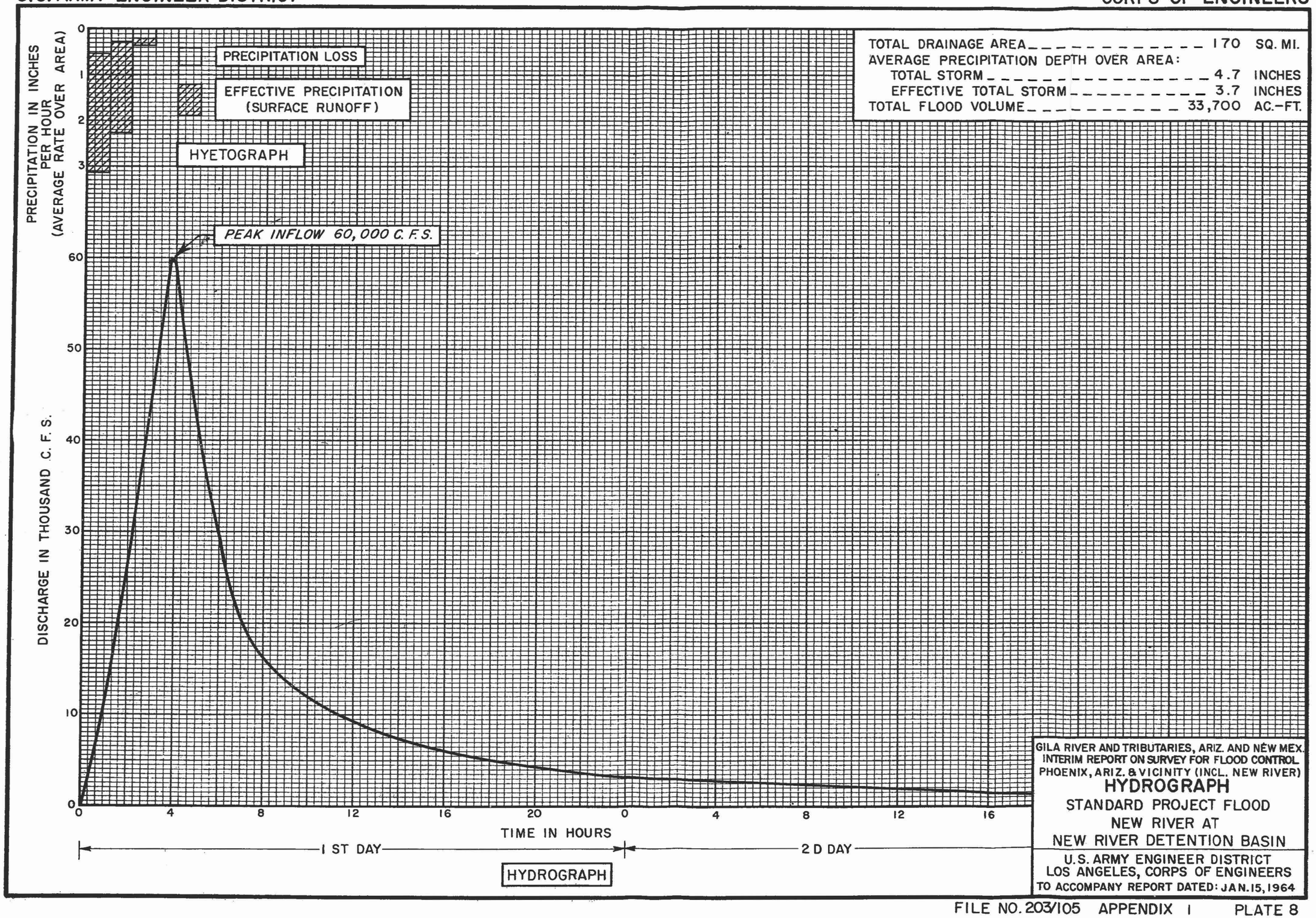
GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

INTENSITY - DURATION AND DEPTH - AREA CURVES

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



TOTAL DRAINAGE AREA	170	SQ. MI.
AVERAGE PRECIPITATION DEPTH OVER AREA:		
TOTAL STORM	4.7	INCHES
EFFECTIVE TOTAL STORM	3.7	INCHES
TOTAL FLOOD VOLUME	33,700	AC.-FT.

GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

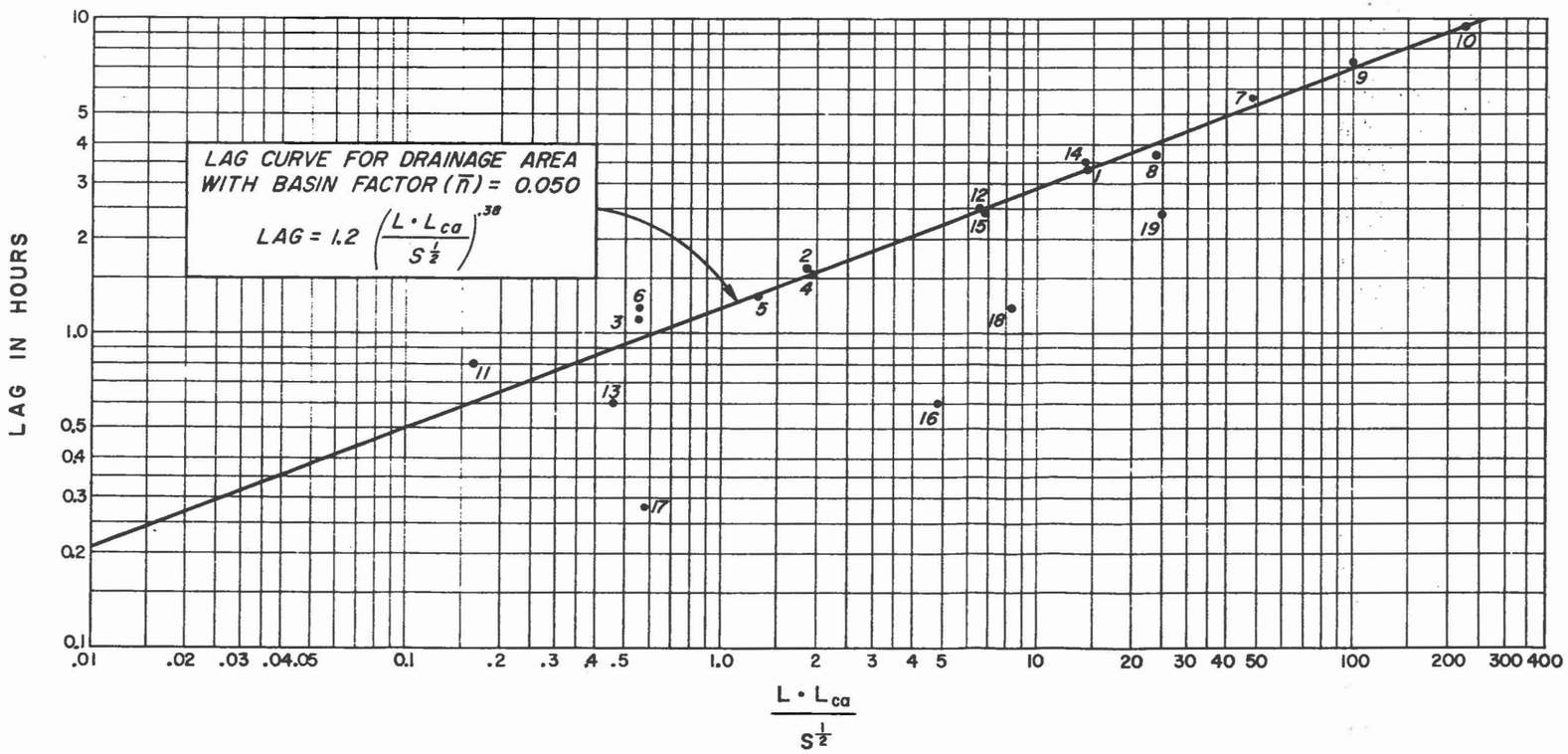
HYDROGRAPH

STANDARD PROJECT FLOOD
NEW RIVER AT
NEW RIVER DETENTION BASIN

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/105 APPENDIX I PLATE 8

		CONTRIBUTING AREA SQ. MI.	L MILES	L_{ca} MILES	S FT./MI.	LAG HOURS	ESTIMATED $\bar{n}$
1.	SAN GABRIEL RIVER AT SAN GABRIEL DAM	162.0	23.2	11.6	350	3.3	0.050
2.	WEST FORK SAN GABRIEL RIVER AT COGSWELL DAM	40.4	9.3	4.2	450	1.6	.050
3.	SANTA ANITA CREEK AT SANTA ANITA DAM	10.8	5.8	2.5	690	1.1	.050
4.	SAN DIMAS CREEK AT SAN DIMAS DAM	16.2	8.6	4.8	440	1.5	.050
5.	EATON WASH AT EATON WASH DAM	9.5	7.3	4.4	600	1.3	.050
6.	SAN ANTONIO CREEK NEAR CLAREMONT	16.9	5.9	3.0	1,017	1.2	.055
7.	SANTA CLARA RIVER NEAR SAUGUS	355.0	36.0	15.8	140	5.6	.050
8.	TEMECULA CREEK AT PAUBA CANYON	168.0	26.0	11.3	150	3.7	.050
9.	SANTA MARGARITA RIVER NEAR FALLBROOK	645.0	46.0	22.0	105	7.3	.055
10.	SANTA MARGARITA RIVER AT YSIDORA	740.0	61.2	34.3	85	9.5	.055
11.	LIVE OAK CREEK AT LIVE OAK DAM	2.3	2.9	1.5	700	.8	.070
12.	TUJUNGA CREEK AT BIG TUJUNGA DAM	81.4	15.1	7.3	290	2.5	.050
13.	EAST FULLERTON CREEK AT FULLERTON DAM	3.1	3.2	1.7	140	.6	.035
14.	LOS ANGELES RIVER AT SEPULVEDA DAM	152.0	19.0	9.0	145	3.5	.050
15.	PACOIMA WASH AT PACOIMA DAM	27.8	15.0	8.0	315	2.4	.050
16.	ALHAMBRA WASH ABOVE SHORT STREET	14.0	9.5	4.6	85	.6	.015
17.	BROADWAY DRAIN ABOVE RAYMOND DIKE	2.5	3.4	1.7	100	.28	.015
18.	BALLONA CREEK AT SAWTELLE BLVD.	88.6	11.8	5.6	64	1.2	.020
19.	SAN JOSE CREEK AT WORKMAN MILL ROAD BRIDGE	81.3	23.7	9.1	75	2.4	.030



GUIDE FOR ESTIMATING BASIN FACTOR ($\bar{n}$)

$\bar{n}$=0.200: DRAINAGE AREA HAS COMPARATIVELY UNIFORM SLOPES AND SURFACE CHARACTERISTICS SUCH THAT CHANNELIZATION DOES NOT OCCUR.. GROUND COVER CONSISTS OF CULTIVATED CROPS OR SUBSTANTIAL GROWTHS OF GRASS AND FAIRLY DENSE SMALL SHRUBS, CACTI, OR SIMILAR VEGETATION. NO DRAINAGE IMPROVEMENTS EXIST IN THE AREA.

$\bar{n}$=0.050: DRAINAGE AREA IS QUITE RUGGED, WITH SHARP RIDGES AND NARROW, STEEP CANYONS THROUGH WHICH WATERCOURSES MEANDER AROUND SHARP BENDS, OVER LARGE BOULDERS, AND CONSIDERABLE DEBRIS OBSTRUCTION. THE GROUND COVER, EXCLUDING SMALL AREAS OF ROCK OUTCROPS, INCLUDES MANY TREES AND CONSIDERABLE UNDERBRUSH. NO DRAINAGE IMPROVEMENTS EXIST IN THE AREA.

$\bar{n}$=0.030: DRAINAGE AREA IS GENERALLY ROLLING, WITH ROUNDED RIDGES AND MODERATE SIDE SLOPES. WATERCOURSES MEANDER IN FAIRLY STRAIGHT, UNIMPROVED CHANNELS WITH SOME BOULDERS AND LODGED DEBRIS. GROUND COVER INCLUDES SCATTERED BRUSH AND GRASSES. NO DRAINAGE IMPROVEMENTS EXIST IN THE AREA.

$\bar{n}$=0.015: DRAINAGE AREA HAS FAIRLY UNIFORM, GENTLE SLOPES WITH MOST WATERCOURSES EITHER IMPROVED OR ALONG PAVED STREETS. GROUND COVER CONSISTS OF SOME GRASSES WITH APPRECIABLE AREAS DEVELOPED TO THE EXTENT THAT A LARGE PERCENTAGE OF THE AREA IS IMPERVIOUS.

TERMINOLOGY

L = LENGTH OF LONGEST WATERCOURSE.

L_{ca} = LENGTH ALONG LONGEST WATERCOURSE, MEASURED UPSTREAM TO POINT OPPOSITE CENTER OF AREA.

S = OVER-ALL SLOPE OF LONGEST WATERCOURSE BETWEEN HEADWATER AND COLLECTION POINT.

LAG = ELAPSED TIME FROM BEGINNING OF UNIT PRECIPITATION TO INSTANT THAT SUMMATION HYDROGRAPH REACHES 50 % OF ULTIMATE DISCHARGE.

$\bar{n}$ = VISUALLY ESTIMATED MEAN OF THE n (MANNING'S FORMULA) VALUES OF ALL THE CHANNELS WITHIN AN AREA.

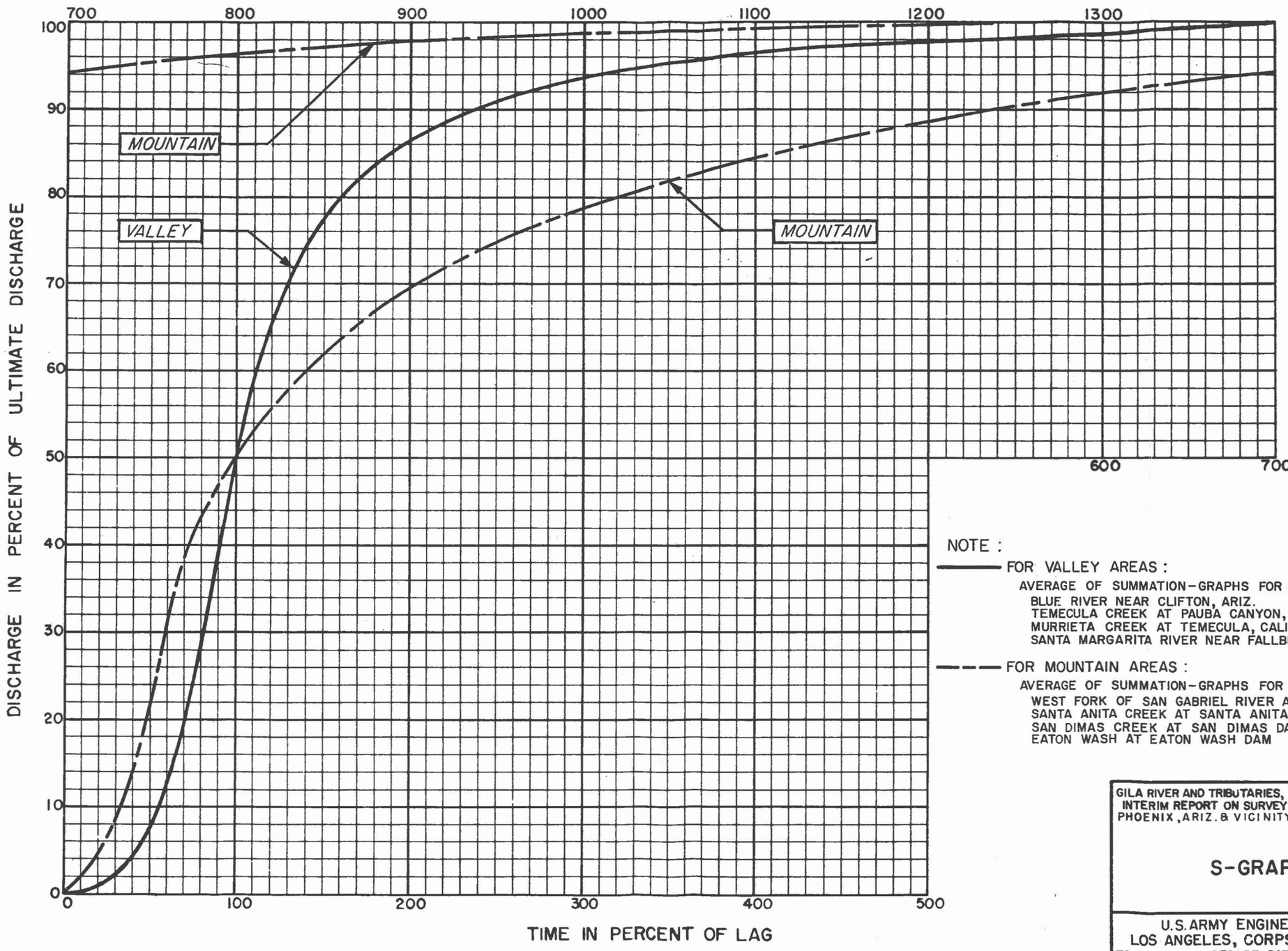
NOTE:
TO OBTAIN THE LAG (IN HOURS) FOR ANY AREA, MULTIPLY THE LAG OBTAINED FROM THE CURVE BY:

$\frac{\bar{n}}{0.050}$ OR $20\bar{n}$

GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

LAG RELATIONSHIPS
STREAMS IN ARIZONA AND SOUTHERN CALIFORNIA

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN.15, 1964



NOTE :

——— FOR VALLEY AREAS :

AVERAGE OF SUMMATION-GRAPHS FOR :
- BLUE RIVER NEAR CLIFTON, ARIZ.
- TEMECULA CREEK AT PAUBA CANYON, CALIF.
- MURRIETA CREEK AT TEMECULA, CALIF.
- SANTA MARGARITA RIVER NEAR FALLBROOK, CALIF.

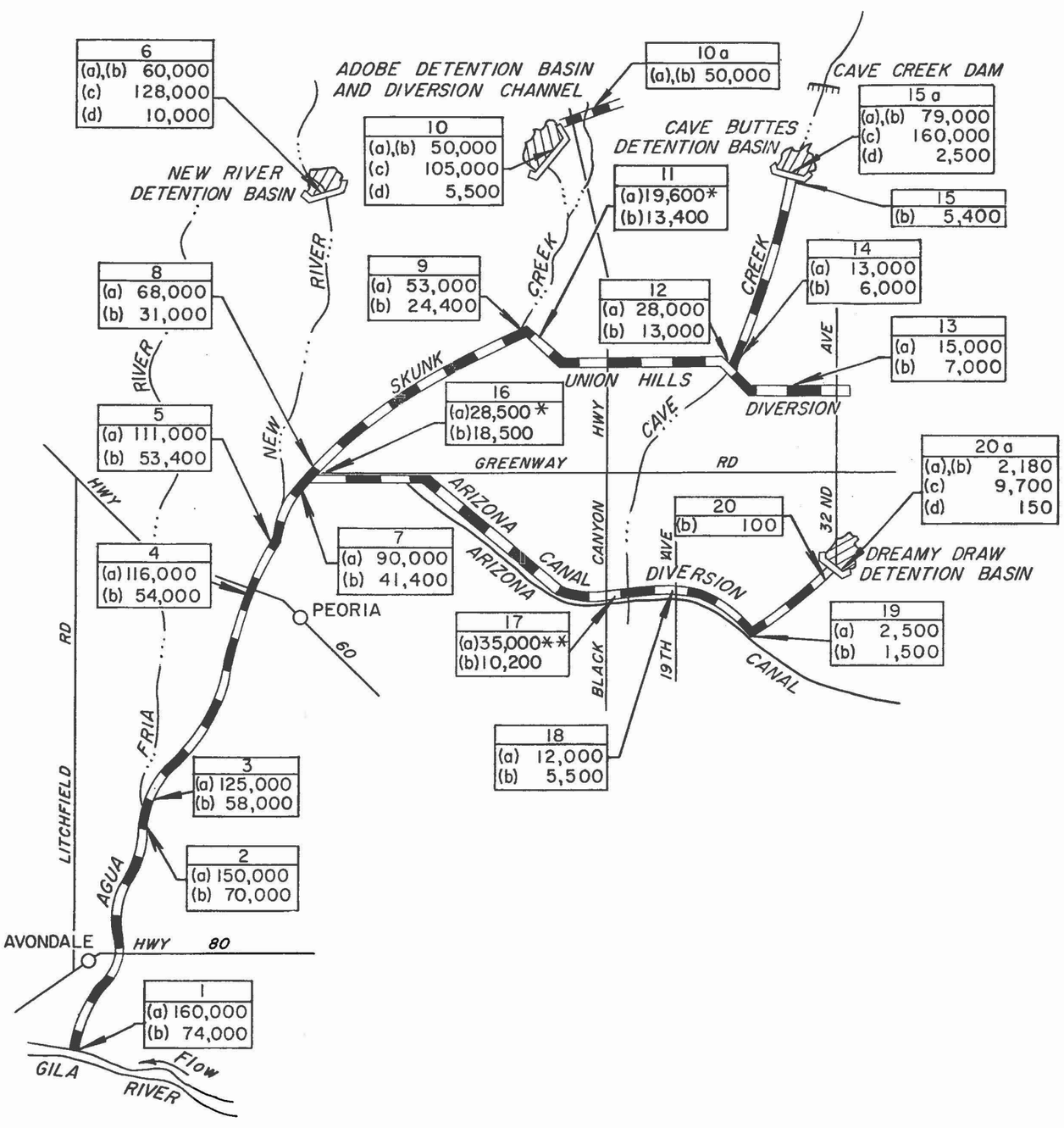
— — — FOR MOUNTAIN AREAS :

AVERAGE OF SUMMATION-GRAPHS FOR :
- WEST FORK OF SAN GABRIEL RIVER AT COGSWELL DAM
- SANTA ANITA CREEK AT SANTA ANITA DAM
- SAN DIMAS CREEK AT SAN DIMAS DAM
- EATON WASH AT EATON WASH DAM

GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

S-GRAPHS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964



LEGEND

EXISTING DAM

RECOMMENDED DETENTION BASIN

RECOMMENDED CHANNEL

15	
(a)	79,000
(b)	79,000
(c)	160,000
(d)	2,500

CONCENTRATION POINT NUMBER
STANDARD-PROJECT-FLOOD PEAK DISCHARGE IN C.F.S.
DESIGN PEAK DISCHARGE IN C.F.S.
MAXIMUM-PROBABLE-FLOOD PEAK DISCHARGE IN C.F.S.
SEDIMENT STORAGE IN AC.-FT.

* TOTAL CAPACITY OF DIVERSION CHANNELS, INCLUDING FREEBOARD, DIVERTED TO SKUNK CREEK

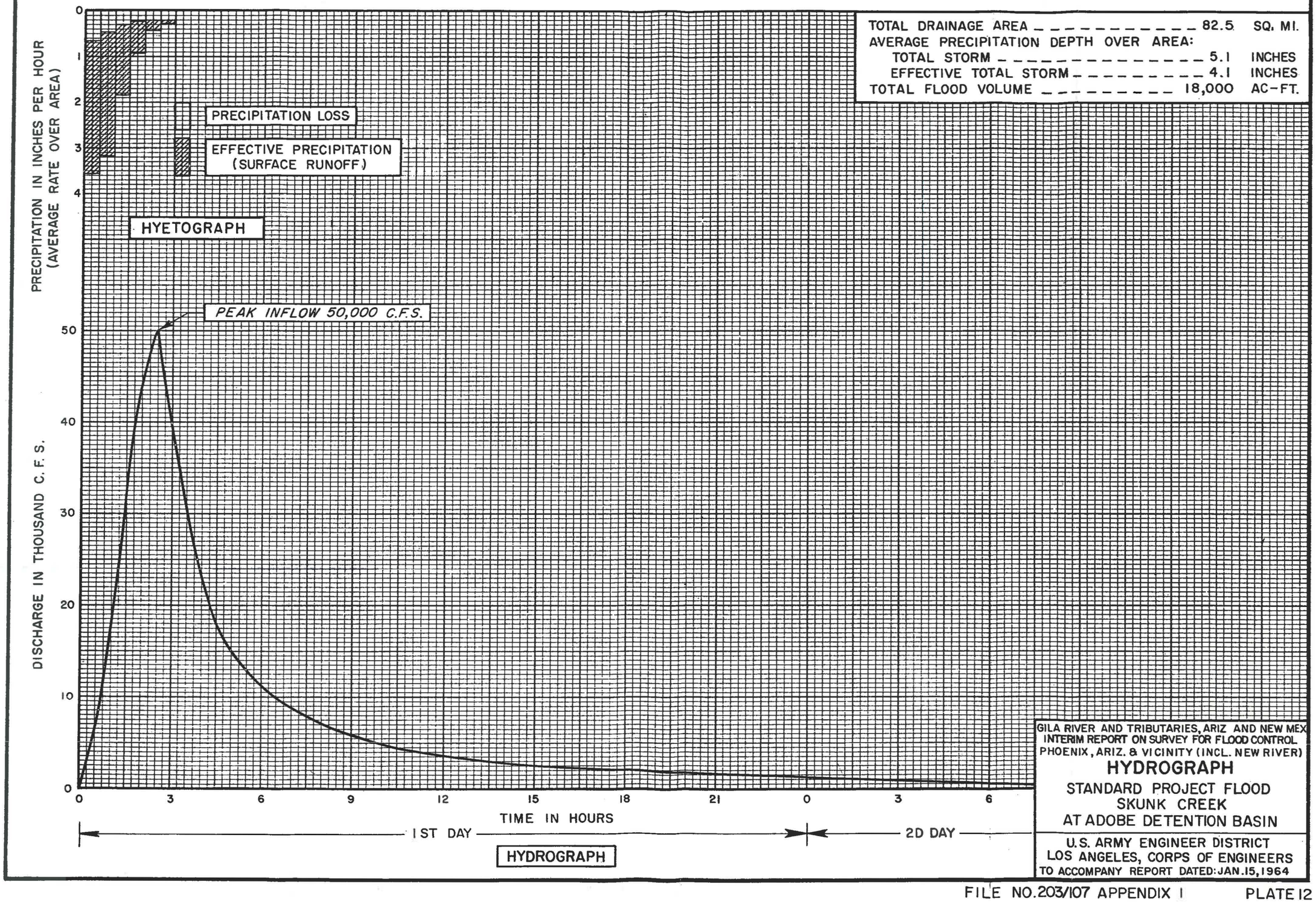
** EXCLUDES ALL FLOW UPSTREAM FROM UNION HILLS DIVERSION CHANNEL.

NOT TO SCALE

GILA RIVER & TRIBUTARIES, ARIZ. & NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

STANDARD-PROJECT-FLOOD PEAK DISCHARGES AND DESIGN VALUES

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964



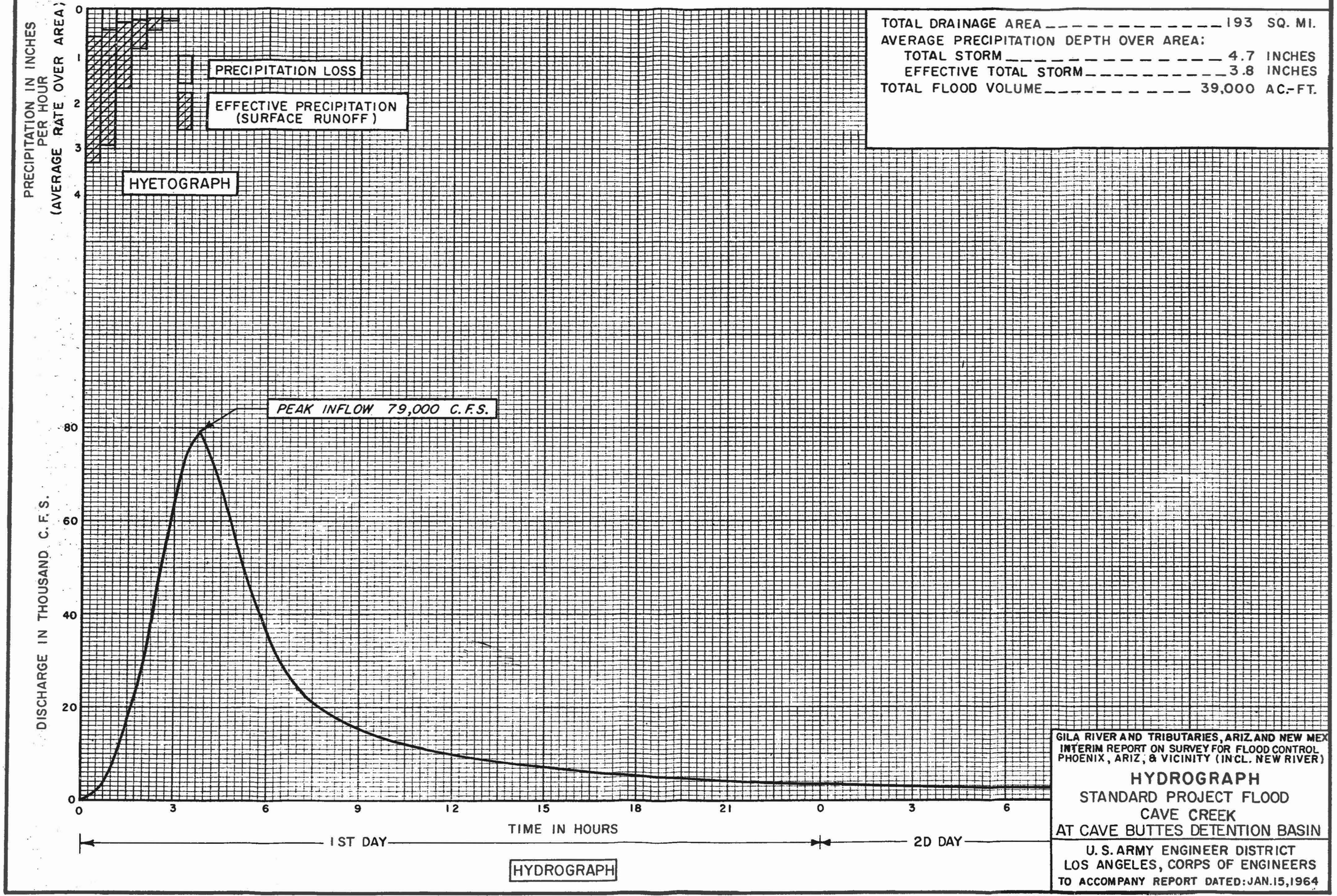
GILA RIVER AND TRIBUTARIES, ARIZ AND NEW MEX
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

HYDROGRAPH

STANDARD PROJECT FLOOD
SKUNK CREEK
AT ADOBE DETENTION BASIN

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

U.S. ARMY ENGINEER DISTRICT — CORPS OF ENGINEERS



TOTAL DRAINAGE AREA	193 SQ. MI.
AVERAGE PRECIPITATION DEPTH OVER AREA:	
TOTAL STORM	4.7 INCHES
EFFECTIVE TOTAL STORM	3.8 INCHES
TOTAL FLOOD VOLUME	39,000 AC.-FT.

GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ, & VICINITY (INCL. NEW RIVER)

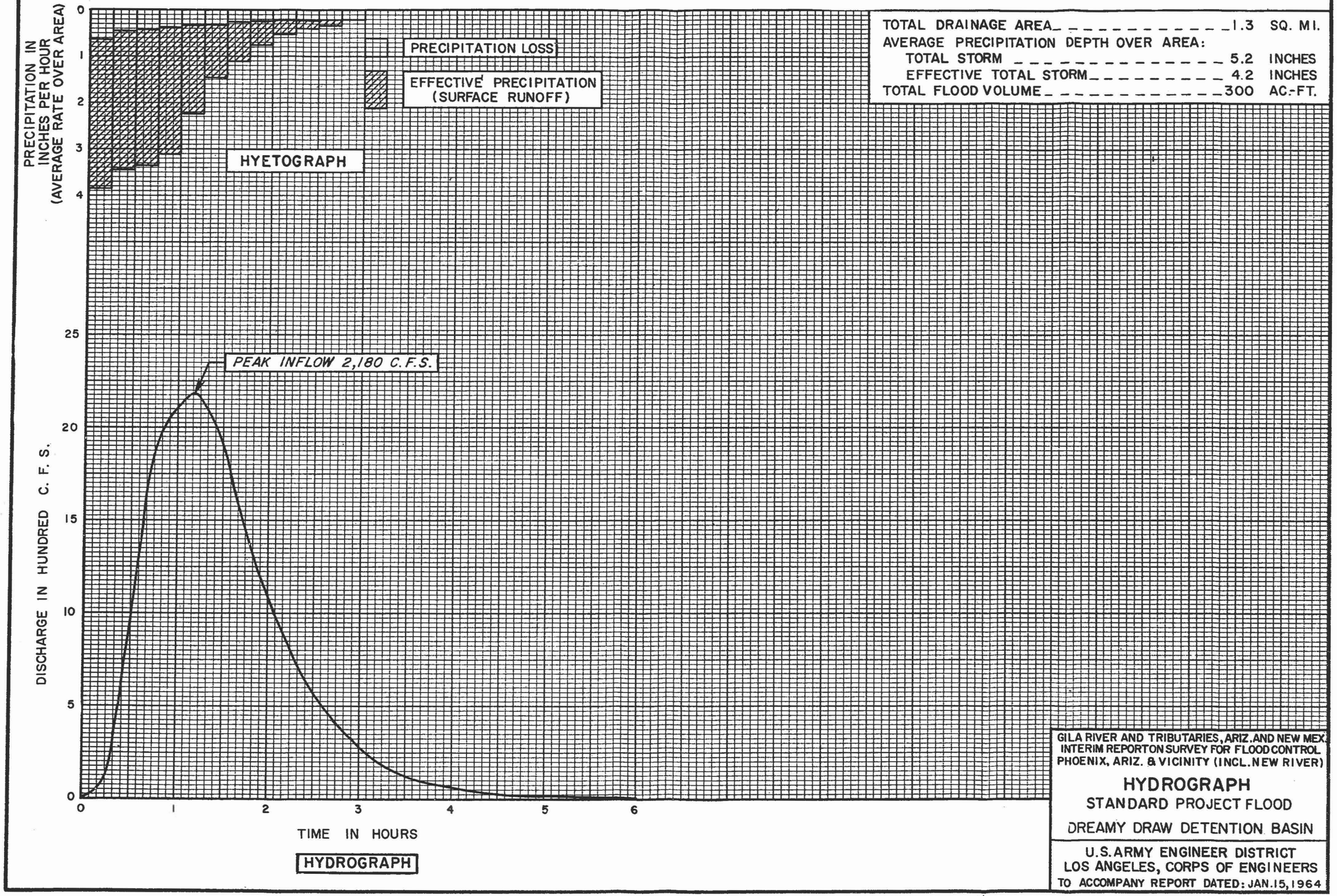
HYDROGRAPH
STANDARD PROJECT FLOOD
CAVE CREEK
AT CAVE BUTTES DETENTION BASIN

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/108 APPENDIX I PLATE 13

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



TOTAL DRAINAGE AREA	1.3	SQ. MI.
AVERAGE PRECIPITATION DEPTH OVER AREA:		
TOTAL STORM	5.2	INCHES
EFFECTIVE TOTAL STORM	4.2	INCHES
TOTAL FLOOD VOLUME	300	AC.-FT.

GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

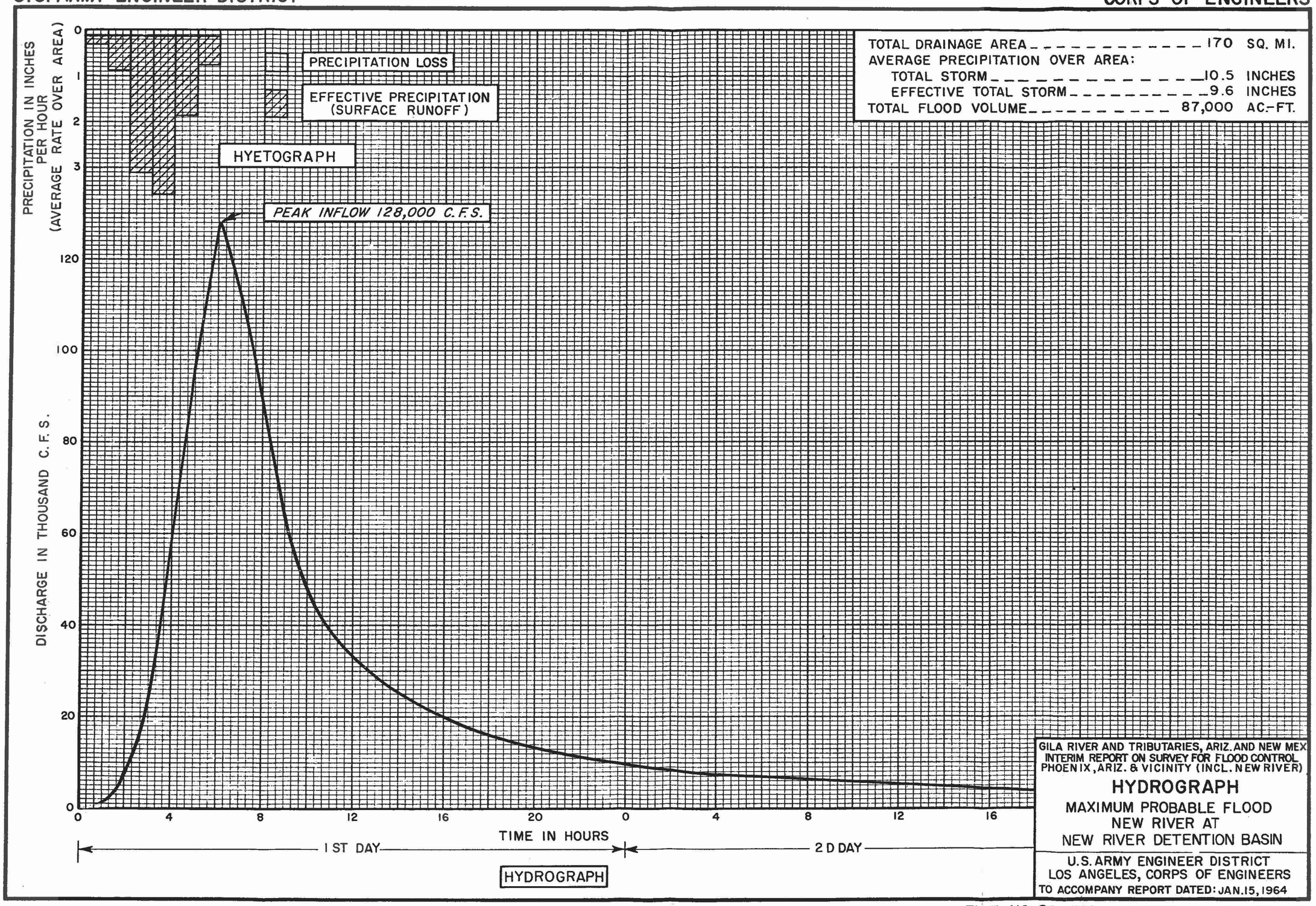
HYDROGRAPH

STANDARD PROJECT FLOOD

DREAMY DRAW DETENTION BASIN

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/109 APPENDIX I PLATE 14



TOTAL DRAINAGE AREA	170	SQ. MI.
AVERAGE PRECIPITATION OVER AREA:		
TOTAL STORM	10.5	INCHES
EFFECTIVE TOTAL STORM	9.6	INCHES
TOTAL FLOOD VOLUME	87,000	AC.-FT.

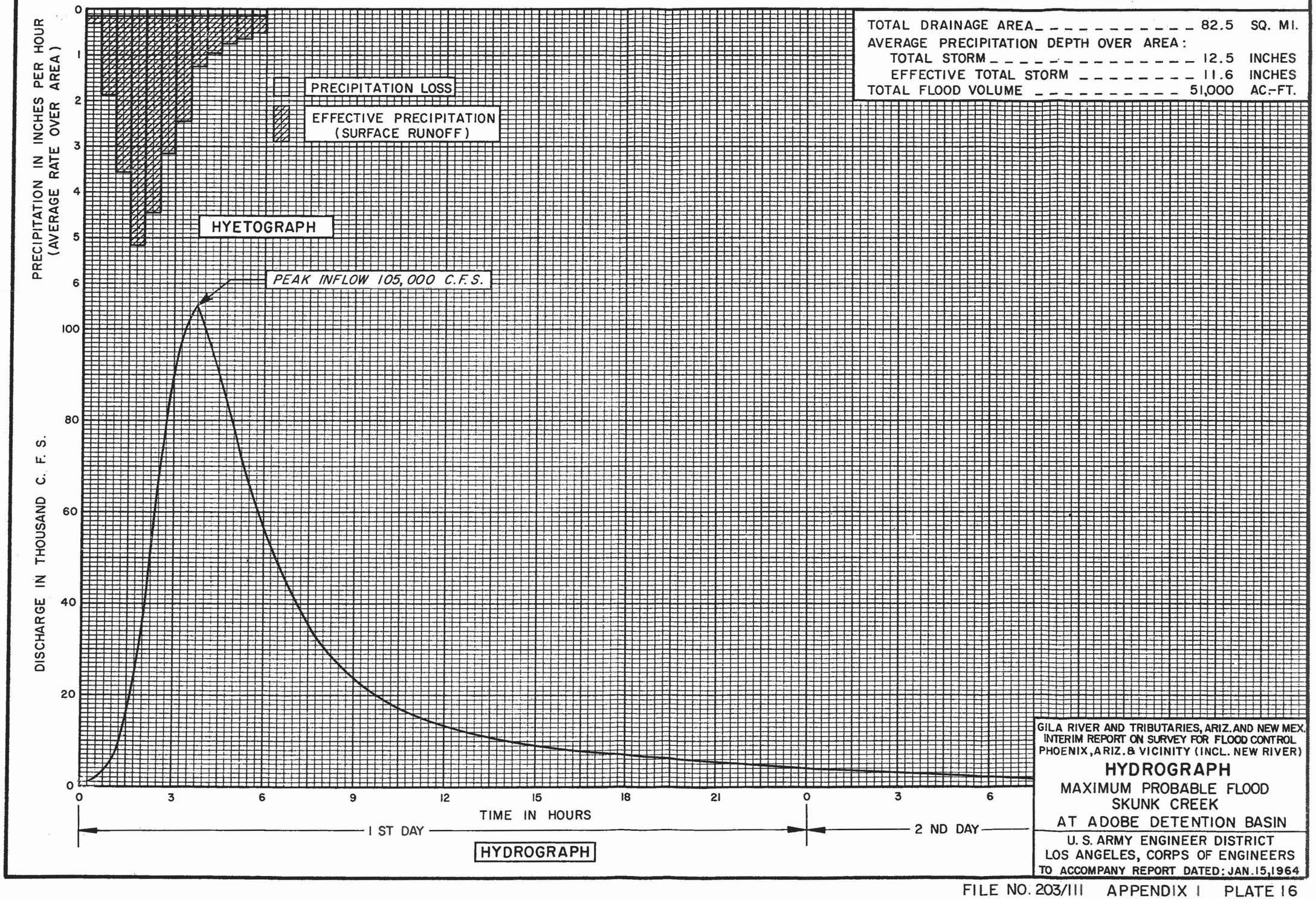
GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

HYDROGRAPH

MAXIMUM PROBABLE FLOOD
NEW RIVER AT
NEW RIVER DETENTION BASIN

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/110 APPENDIX I PLATE 15



GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

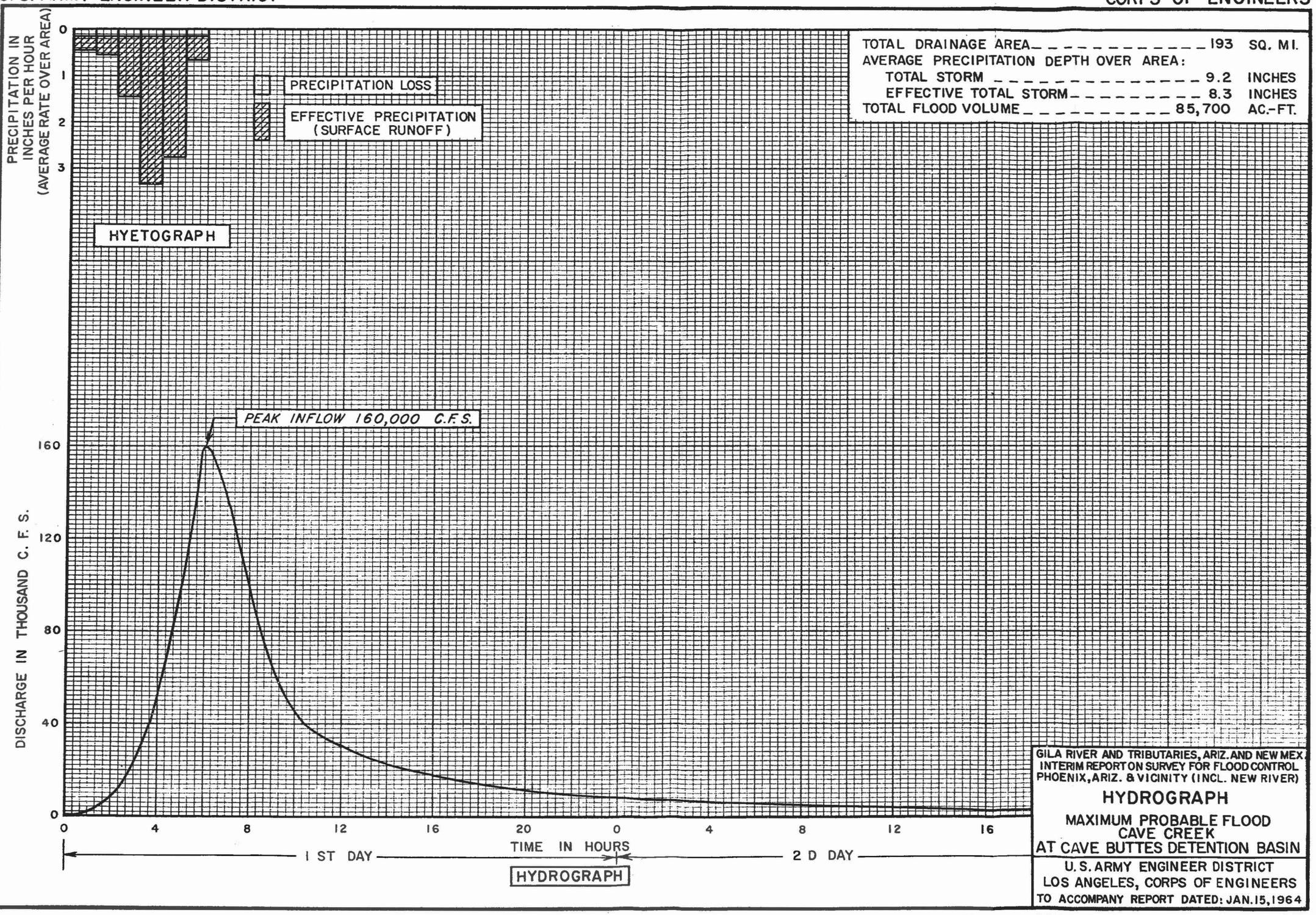
HYDROGRAPH

MAXIMUM PROBABLE FLOOD
SKUNK CREEK
AT ADOBE DETENTION BASIN

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

U. S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



TOTAL DRAINAGE AREA	193	SQ. MI.
AVERAGE PRECIPITATION DEPTH OVER AREA:		
TOTAL STORM	9.2	INCHES
EFFECTIVE TOTAL STORM	8.3	INCHES
TOTAL FLOOD VOLUME	85,700	AC.-FT.

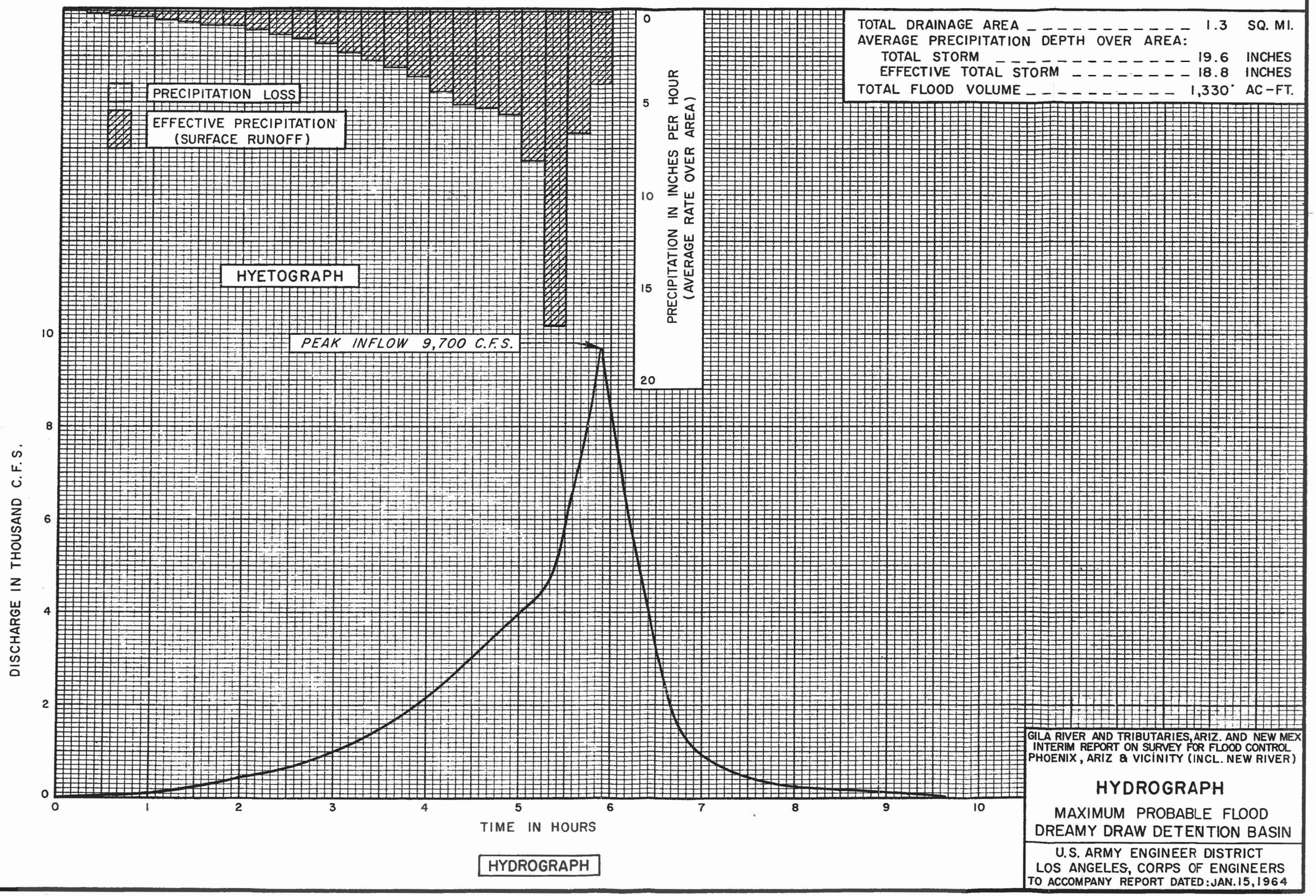
GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

HYDROGRAPH

MAXIMUM PROBABLE FLOOD
CAVE CREEK
AT CAVE BUTTES DETENTION BASIN

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/112 APPENDIX I PLATE 17



TOTAL DRAINAGE AREA	1.3	SQ. MI.
AVERAGE PRECIPITATION DEPTH OVER AREA:		
TOTAL STORM	19.6	INCHES
EFFECTIVE TOTAL STORM	18.8	INCHES
TOTAL FLOOD VOLUME	1,330	AC-FT.

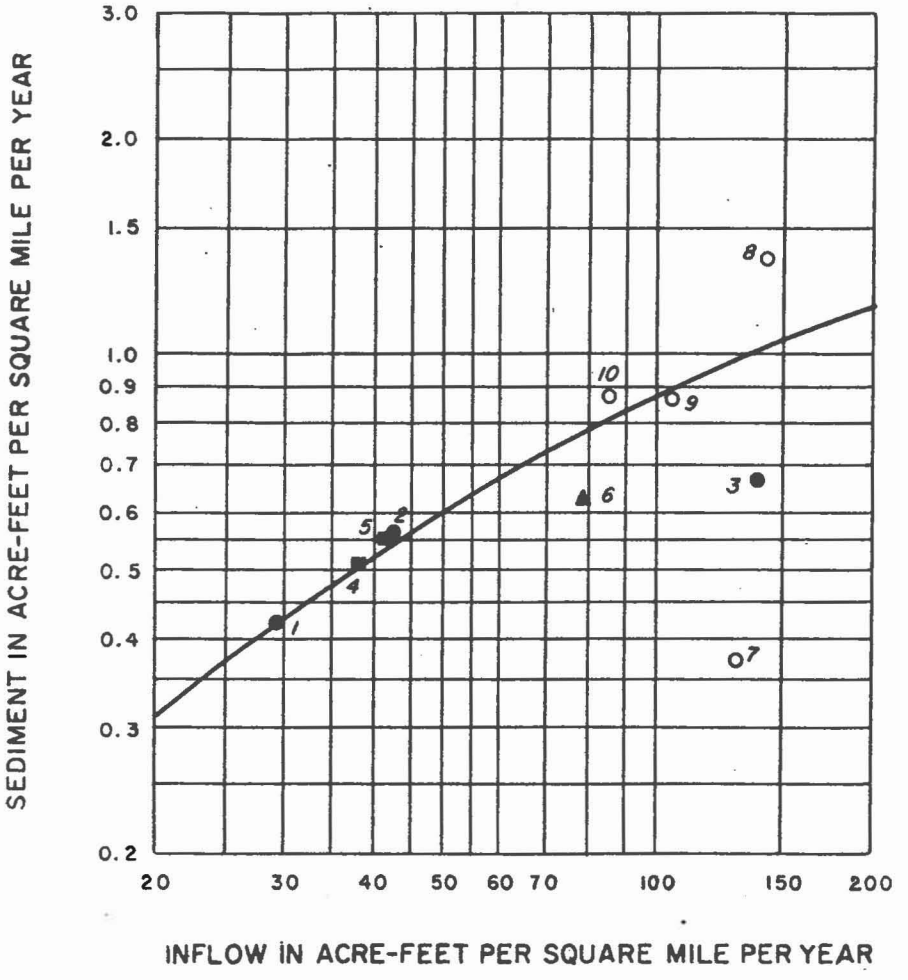
GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ & VICINITY (INCL. NEW RIVER)

HYDROGRAPH

MAXIMUM PROBABLE FLOOD
DREAMY DRAW DETENTION BASIN

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS



LEGEND

- ● ARIZONA RESERVOIRS
- ■ NEW MEXICO RESERVOIRS
- ▲ NEVADA-ARIZ. RESERVOIR (LAKE MEAD)
- O CALIFORNIA RESERVOIRS

NOTE:

POINTS ARE NUMBERED TO CORRESPOND WITH RESERVOIRS SHOWN IN TABLE 2

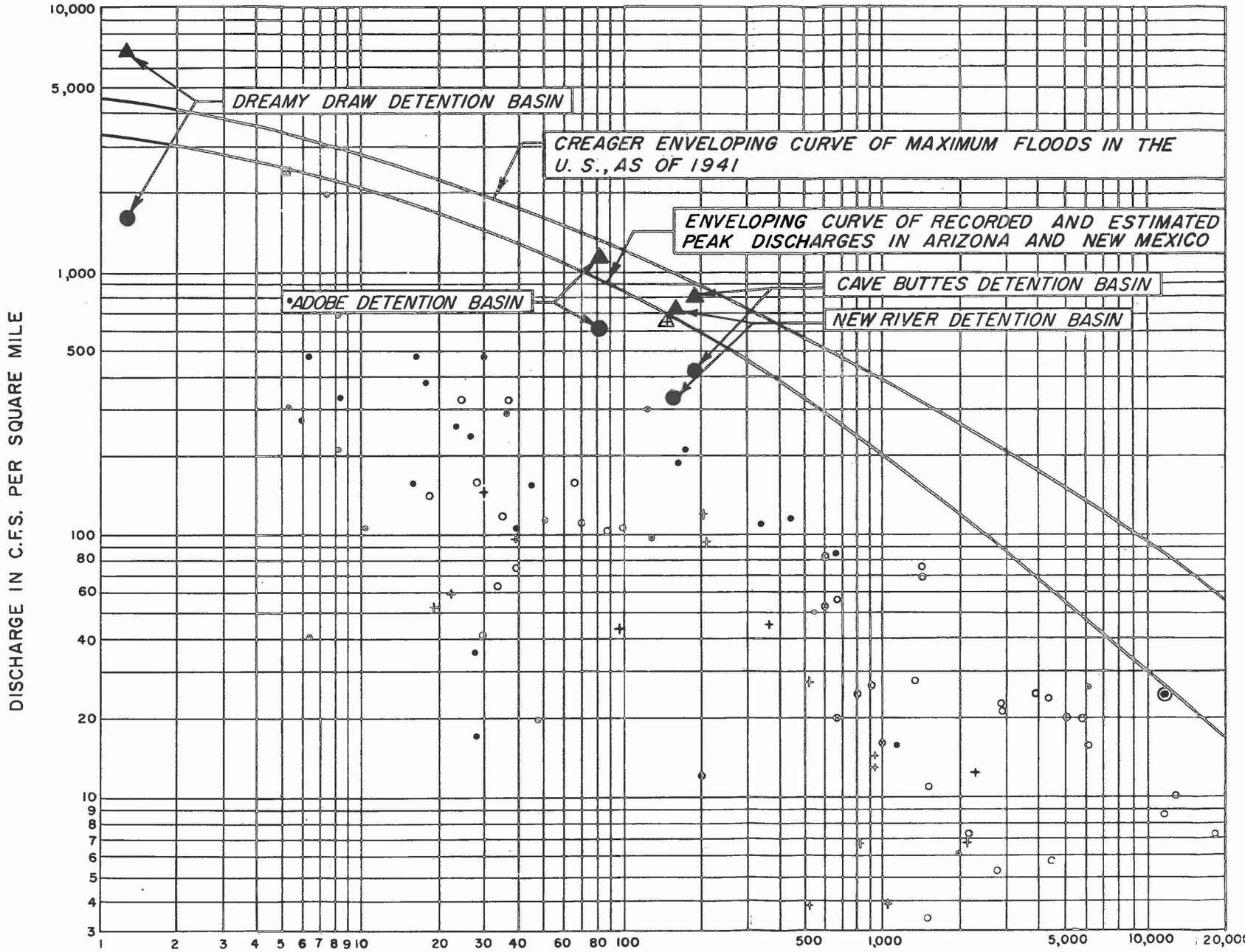
THIS DRAWING SUPERSDES DWG. FILE NO. 203/114

GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

INFLOW-SEDIMENT RELATIONSHIP FOR CONSERVATION RESERVOIRS IN SOUTHWESTERN UNITED STATES

OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/114.1 APPENDIX I PLATE 19



LEGEND

- ○ FLOODS FROM GENERAL RAIN OR SNOW MELT RUNOFF
- \+ FLOODS FROM LOCAL SUMMER STORMS.
- • FLOOD TYPE UNDETERMINED.
- ⊞ ALDER CREEK AT MOUTH-LOCAL STORM.
- ⧋ BEAR CREEK AT MOUTH-LOCAL STORM.
- ◉ SALT RIVER AT GRANITE REEF DAM – GENERAL STORM.
- ● STANDARD PROJECT FLOOD.
- ▲ MAXIMUM PROBABLE FLOOD.

GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

ENVELOPING CURVES OF PEAK DISCHARGES

STREAMS IN ARIZONA AND NEW MEXICO

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

APPENDIX 2 - BASES FOR DESIGN

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

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B A S E S F O R D E S I G N

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

SCOPE

1. This appendix covers the engineering aspects of the improvements for flood control recommended for construction in the vicinity of Phoenix, Maricopa County, Ariz. The locations of the improvements are shown on plates 1 and 3 of the main report, and details of improvements considered are shown on plates 1 to 20, inclusive, of this appendix.

IMPROVEMENTS CONSIDERED

2. The recommended improvements were designed so that the detention basins would control the standard project flood and the channel improvements would be entrenched in the ground with capacities adequate to convey discharges corresponding to those of a flood with a frequency of occurrence of once in 100 years. The recommended improvements would include the following:

Adobe detention basin and diversion channel.
Cave Buttes detention basin.
Cave Creek channel.
Union Hills diversion channel.
Dreamy Draw detention basin.
Arizona Canal diversion channel and Dreamy Draw channel.
Skunk Creek channel.
New River detention basin.
New River and Agua Fria River channelization.

Adobe Detention Basin and Diversion Channel

3. Recommended plan.--The detention basin would be constructed on an unnamed tributary of Skunk Creek, between the Deem Hills and Middle Mountain, about 14 miles north of Phoenix. The diversion channel and levee would be constructed across the Skunk Creek flood plain to divert flows into the detention basin.

4. The improvement would consist of an earthfill embankment, an ungated outlet, a detached spillway in a saddle on the left abutment, and an earth diversion channel and levee. (See pl. 1.) The earthfill embankment would have a crest length of about 3,850 feet, crest elevation of 1,561 feet above mean sea level, a top width of 20 feet, upstream slope of 1 vertical on $2\frac{1}{2}$ horizontal, a downstream slope of 1 vertical on 2 horizontal, and a maximum height of about 76 feet.

5. The outlet would consist of an 8-foot-diameter reinforced-concrete conduit with a log rack at the inlet. The unlined spillway would be excavated in rock and would have a concrete sill; the crest length would be 250 feet, and the crest elevation would be 1,542 feet.

6. The diversion channel would be excavated in earth and would be about 2 miles long. It would be unlined and trapezoidal in cross section with side slopes of 1 vertical on 2 horizontal. The base width would be 500 feet, and the average depth would be 12 feet. A levee, about $1\frac{1}{2}$ miles long, would extend from high ground on the east side of the detention basin, across the highway, and to high ground on the east bank of Skunk Creek. The levee and channel would be separated by a 100-foot berm. The levee would have an upstream slope of 1 vertical on $2\frac{1}{2}$ horizontal and downstream slope of 1 vertical on 2 horizontal. The levee would have a top width of 20 feet, an average height of about 12 feet, and revetment on the water side with 18 inches of stone underlain by 6 inches of gravel filter. The revetment would extend from the top of the levee to 5 feet below the channel invert. Black Canyon Highway would cross over the levee, and a bridge would be built over the channel.

7. Hydraulic design.--The area-capacity curve was based on aerial topography furnished by the Maricopa County Flood Control District, dated 1963. Reservoir areas were determined at contour intervals of 5 feet, and the gross volume was determined for these intervals. The net capacity curve was determined by deducting the sediment volume from the gross capacity, the sediment volume at any elevation being the ratio: area at any elevation is to the area at the spillway crest as the volume is to total volume. (See pl. 1.) The dam outlet would have a maximum capacity of 2,000 cubic feet per second. (See fig. 1.)

8. The standard project flood was routed through the reservoir that was assumed to contain a 100-year sediment volume distributed to the spillway crest. The routing was made by standard flood-routing methods previously used.

The spillway-crest elevation was set coincident with the water-surface elevation obtained for the reservoir-design flood. The spillway-design flood (maximum probable) was routed by assuming the reservoir-design-flood (standard project) peak had preceded the maximum probable flood by about 25 hours. A graph showing the relationship between inflow-outflow and the reservoir water surface is shown on figure 2. The required freeboard was predicated on wave height and on rideup and setup above the water surface in accordance with information obtained by the spillway-design-flood routing. A freeboard of 5 feet as a minimum was selected although the computation showed 3.6 feet would be required.

9. The excavated channel would have a bank-full capacity equal to the peak discharge of the standard project flood under the design assumption that n = .03 and no sediment deposits. However, there is a good possibility that the capacity of the channel would be reduced by sediment deposit at points of major inflow. A levee along the south side of the excavated channel would be provided to assure diversion of the design flood under adverse conditions. The levee required to effect diversion of the design flood under these adverse conditions (obstruction by sediment deposits and n = .03) would, under ideal conditions (no obstruction and n = .02), divert the maximum probable flood. Therefore, the diversion of the maximum probable flood was assumed in the design of Adobe Dam and spillway. Refinement of design details for the general-design memorandum may permit a reduction in design for Adobe Dam. However, for this survey report, a conservative assumption is retained. Under design conditions, the main velocity in the channel would be about 9 feet per second. Black Canyon Highway would cross the channel on a 500-foot-long bridge.

10. Pertinent data.--Pertinent data on the Adobe detention basin are given in the following table:

Drainage area and design values

Drainage area	sq. miles	82.5
Reservoir-design flood:		
Peak inflow	c.f.s.	50,000
Volume	acre-ft.	18,020
Spillway-design flood:		
Peak inflow	c.f.s.	105,000
Volume	acre-ft.	51,210
Sediment-storage requirement (100-yr. period)	acre-ft.	5,500

General

Reservoir:		
Area	acre	1,050
Capacity	acre-ft.	19,400
Embankment:		
Top elevation	ft., m.s.l.	1,561
Maximum height	ft.	76
Length	ft.	3,850
Freeboard	ft.	5.0
Spillway:		
Crest elevation	ft., m.s.l.	1,542
Pool-drain conduit:		
Capacity	c.f.s.	2,000
Diameter	in.	96

11. Geology and soils.--Pertinent information on geology and soils at the site of the Adobe detention basin and diversion channel is given in following subparagraphs.

(a) Explorations.--Explorations for the proposed damsite were completed during February 1963. Ten test trenches were excavated to depths ranging from 3 to 14 feet with a D-8 dozer that was equipped with a hydraulic-controlled ripper. One test trench was excavated in the right abutment, two at the toe of the right abutment for the outlet works, four across the valley bottom, two in the left abutment, and one in the spillway. Disturbed samples of the soil were obtained for laboratory classification tests. The location and logs of the trenches are presented on plate 2.

(b) Foundation conditions.--The surface material on the right abutment consists of volcanic cobbles, boulders, and volcanic rocks that could not be penetrated with the D-8 dozer; the surface material is probably underlain by agglomerate. Ground water was not encountered, but it is probably at a depth of 50 feet or more.

(c) The trenches for the outlet works, which were excavated near the toe of the right abutment, encountered silt and sand to a depth of 8 feet; below a depth of 8 feet, cobbles and boulders in a moderately cemented matrix were encountered. The materials encountered in the trenches across the valley bottom consisted of a surface layer about 4 feet thick of silty sand, silt, and clay that was underlain by partially cemented silty gravelly sand containing cobbles and small boulders; the degree of cementation increased with depth,causing the materials to be difficult to penetrate with a ripper below depths of 8 to 10 feet.

(d) The trench excavated at the toe of the left abutment encountered sandy silt to a depth of 10 feet that was underlain by moderately well-cemented agglomerate. A trench excavated on the left abutment about elevation 1,530 feet encountered a surface layer about 4 feet thick of volcanic cobbles and boulders derived from a remnant of a basalt cap; the surface layer was underlain by moderately weathered, slight to moderately cemented, tuffaceous agglomerate.

(e) At the site of the spillway, the material from the ground surface to a depth of 1 foot was silt containing a few cobbles and boulders; from a depth of 1 to 2.5 feet, hard caliche was encountered; from 2.5 to 5 feet, moderately cemented silty sand was encountered; and from 5 to 12 feet, tuffaceous agglomerate was encountered.

(f) Design applications.--Pertinent information on design applications is given in following subparagraphs.

(1) Embankment.--Material for construction of the embankment could be obtained by excavating to a depth of about 10 feet in the valley bottom upstream from the embankment. The materials are very dry and will have to be moistened to optimum moisture with imported water. Material for pervious drains could be obtained by processing streambed material from Skunk Creek.

(2) The materials in the abutments and valley bottom have ample strength to support the embankment. Settlement of the foundation will not be a problem. The depth of stripping across the valley bottom should be about 1 foot; and on the abutments, 5 feet. An exploration trench should be provided for the entire length of the embankment; it should extend 10 feet below the ground line across the valley bottom and 10 feet below the stripping line on the abutment; the bottom width should be 12 feet, and the side slopes should be 1 vertical on 3 horizontal. The exploration trench would be backfilled with compacted random materials from the borrow area.

(3) The embankment would be constructed from random materials obtained from the borrow area. After compaction, these materials would be relatively impervious. With the exploration trench tied to cemented material across the valley bottom and to agglomerate on the abutments, the embankment would create an impervious barrier, and there would be little if any underseepage during the short period that water would be stored in the reservoir. Throughseepage would not occur because the saturation line would not penetrate an appreciable distance into the embankment during the short period of impoundment. Hence, both slopes would be designed for a drained condition. An upstream slope of 1 on 2.5 and a downstream slope of 1 on 2 would have adequate safety factors against failure in shear. It is anticipated that enough cobbles could be raked out of the embankment to provide protection against erosion on the upstream and downstream slopes. An inclined pervious chimney connected to a horizontal downstream drain would be provided for internal drainage.

(4) Outlet.--At the toe of the left abutment, the outlet can be safely founded on cemented material found at elevation 1,484 feet, which is about 8 feet below the existing ground surface.

(5) Spillway.--The ground surface in the spillway area is about elevation 1,540 feet. If the crest elevation of the spillway is established at elevation 1,535 feet or lower, the crest would be in agglomerate that would be fairly scour resistant.

(6) Collecting dike.--Side slopes of 1 on 2 would be stable. The upstream slope would be revetted with an 18-inch layer of 150-pound stone underlain by a 6-inch layer of gravel filter.

Cave Buttes Detention Basin

12. Recommended plan.--Cave Buttes detention basin would be constructed about 2 miles south of the existing Cave Creek Dam. The site is accessible by way of Cave Creek Road. The improvement would consist of an earthfill dam with an ungated outlet on the main-stream channel, east and west dikes, and a detached spillway on the right abutment. The principal features are shown on plate 3.

13. The earthfill embankments would have a crest elevation of 1,621 feet, a top width of 20 feet, upstream slope of 1 vertical on $2\frac{1}{2}$ horizontal, and a downstream slope of 1 on 2. The main dam would have a crest length of about 2,100 feet and a maximum height of about 120 feet. The west dike would have a crest length of about 3,500 feet and a maximum height of about 90 feet. The east dike would have a crest length of about 8,600 feet and a maximum height of about 75 feet. The easternmost 1,500 feet of the east dike would serve as a deflecting levee for spillway flows from the existing Cave Creek Dam. The deflecting levee would be about 6 feet high.

14. The outlet would consist of a 12-foot-diameter concrete conduit with a log rack at the inlet. It would empty into the Cave Creek channel. The unlined spillway would be excavated in rock with a crest length of 400 feet and a concrete sill at the crest elevation 1,596.5 feet.

15. Hydraulic design.--The area-capacity curve was computed, based on aerial topography dated 1961. The reservoir area was determined at contour intervals of 5 feet and the gross volume was determined for these intervals. The net capacity curve was determined by deducting the sediment volume from the gross capacity; the sediment volume at any elevation being the following ratio: area at any elevation is to the area at the spillway crest as the volume is to the total volume. (See pl. 3 for the area-capacity curve.) The dam outlet would have a maximum capacity of 5,430 cubic feet per second. (See fig. 3.) The standard project flood was routed through the reservoir that was assumed to contain a 100-year sediment volume distributed to the spillway crest. The routing was made by standard flood-routing methods previously used. The spillway-crest elevation was set coincident with the water-surface elevation obtained for the reservoir-design flood.

16. The spillway-design flood (maximum probable) was routed by assuming the reservoir-design-flood (standard project) peak had preceded the maximum probable peak by 2 days. A graph showing the relationship between inflow-outflow and the reservoir water surface is shown on figure 4. The required freeboard was predicated on wave height and on rideup and setup above the water surface in accordance with information obtained by the spillway-design-flood routing. A freeboard of 5.5 feet was selected although the computation showed 4.6 feet would be sufficient.

17. Pertinent data.--Pertinent data on the Cave Buttes detention basin are given in the following table:

Drainage area and design values

Drainage area.....sq. miles..	193.0
Reservoir-design flood:	
Peak inflow.....c.f.s..	79,000
Volume.....acre-ft..	39,000
Spillway-design flood:	
Peak inflow.....c.f.s..	160,000
Volume.....acre-ft..	85,700
Sediment-storage requirement (100-yr. period).....acre-ft..	2,500

General

Reservoir:	
Area.....acre..	825
Capacity.....acre-ft..	28,800
Embankment:	
Top elevation.....ft., m.s.l..	1,621
Maximum height.....ft..	110
Length.....ft..	2,100
Freeboard.....ft..	5.5
Spillway:	
Crest elevation.....ft., m.s.l..	1,596.5
Pool-drain conduit:	
Capacity.....c.f.s..	5,400
Diameter.....in..	144

18. Geology and soils.--The main embankment would span Cave Creek between two volcanic hills. The hill forming the left abutment has a volcanic cover of basalt. The upper slopes are covered with talus consisting of basalt boulders, and the lower slopes are covered with residual soil and basalt boulders. The hill forming the right abutment is composed of basalt flows with a hard, coarse basalt breccia exposed near the base of the abutment. The valley bottom between the hills as exposed in two trenches is composed of sand, gravel, cobbles, and boulders of a maximum size of about 24 inches to a depth of at least 25 feet; the granular materials on the left side of the valley are covered with at least 5 feet of silt and clay containing basaltic boulders.

19. The spillway would be excavated through a saddle in the ridge of the hill forming the right abutment. The crest of the saddle is covered with residual soil and basaltic rock fragments (containing caliche near the surface) that are probably underlain at an undetermined depth by a coarse agglomerate with a tuffaceous matrix.

20. The right end of the east dike abuts the northeast side of the hill forming the left abutment of the main embankment. Geologic conditions where the dike abuts the hill are not known, except that a coarse agglomerate with a tuff matrix is exposed at the base of the butte, about 1,600 feet westward of the abutment, and that the lower slopes of the hill are composed of residual soil and basalt boulders and some talus deposits. The left end of the east dike abuts a low-lying ridge that has fractured volcanic bedrock exposed at the top of the hill and residual soil with basaltic boulders covering the lower slopes. The alluvial plain between the volcanic hill and low-lying ridge is composed of silty sand-clayey sand to undetermined depths with some caliche exposed at the surface; the deflecting dike northeastward of the east dike would cross a topography and be in materials similar to that of the alluvial plain southwestward of the low ridge.

21. The left end of the west dike abuts the north end of the same hill forming the right abutment of the main embankment. Outcrops of bedrock near the dike but about one-third the distance up the slope of the abutment indicate the hill in this area is composed of volcanic agglomerate with the lower slopes covered by talus and residual soil containing rock fragments and boulders. The right abutment has a residual cover of basaltic and granitic fragments, but the mass of the hill is probably granite that is cut by volcanic dikes; schist is exposed in the gullies on the lower slopes, and granite is exposed above the schist. The alluvial plain between the abutments is composed of silty sand-clayey sand to undetermined depths with some caliche exposed at the surface.

22. Adequate quantities of borrow materials would be available for construction of the proposed embankments. Impervious materials consisting of silty sand-clayey sand containing some gravel and occasional cobbles of a maximum size of 18 inches could be obtained from the unnamed wash located immediately north of the east dike; this material is exposed in an abandoned materials pit with a depth of about 15 feet. Material for the pervious drain could be obtained by processing the granular material in the streambed immediately upstream from the main embankment.

23. The embankments would be constructed of pit-run impervious materials with a pervious chimney and downstream horizontal pervious drain. The foundation materials and the abutments would adequately support the proposed embankment. No settlement or stability problems are anticipated. Underseepage beneath the dikes would be controlled by connecting the impervious section to the impervious foundation materials. Underseepage beneath the main embankment would be uncontrolled, but piping of the coarse foundation materials would not be expected. Throughseepage would be controlled by the pervious chimney and downstream drain.

Cave Creek Channel

24. Recommended plan.--The channel would be constructed along Cave Creek from Cave Buttes detention basin to the Union Hills diversion channel. It would carry releases from the detention basin outlet and side drainage from the Cave Creek drainage basin. The channel would be about 3.6 miles long. The reinforced-concrete-lined channel would have a trapezoidal cross section, side slopes of 1 vertical on $2\frac{1}{2}$ horizontal, a base width of 10 feet, and a channel depth of 11 feet. The base slab would be 10 inches thick and the side-slope slabs would be 8 inches thick. Berms along the channel would be paved with asphalt. No bridges or utility relocations are anticipated. For details, see plate 5.

25. Hydraulic design.--Cave Creek channel will convey the outflow from Cave Buttes Dam and intercept part of the flow from Cave Creek drainage area downstream from the dam. The selected design discharge of 6,000 cubic feet per second would correspond to a flood with a frequency of occurrence once in 100 years (included is 3,100 c.f.s. outflow from Cave Buttes Dam). The excess flow not entering the channel would be intercepted by the Union Hills diversion channel. The water-surface profile was determined by the reach method with the friction loss evaluated by use of the Manning formula, assuming an "n" value of .014. The channel would terminate in the Union Hills diversion channel. Velocity in the channel would be supercritical and the maximum would be 27 feet per second. The depth of flow would be about 8 feet.

26. Geology and soils.--The channel would be founded on Recent alluvium consisting of sand, gravel, cobbles, and boulders with a maximum size of about 24 inches. Excavation and fill slopes of 1 on 2 would be stable. Although the depth to ground water is not known, a subdrainage system would probably be required.

Union Hills Diversion Channel

27. Recommended plan.--The channel would be constructed in the vicinity of and generally parallel to Union Hills Drive, an east-west road north of Phoenix. It would collect floodwaters from the Cave Creek drainage basin below the proposed Cave Buttes detention basin and above Union Hills Drive and divert them to Skunk Creek. The channel would be about 9-3/4 miles long and would extend from 40th Street to Skunk Creek at Hedgpeth Hills. The reinforced-concrete-lined channel would have a trapezoidal cross section, side slopes of 1 vertical on 2-1/4 horizontal, base width of 15 to 60 feet, and wall heights of 10 to 18 feet. The base slab would be 10 inches thick and the side-slope slabs would be 8 inches thick. Berms along the channel would be paved with asphalt. Seven bridges would be constructed. About 1,800 feet of Union Hills Drive would be relocated. For location and details, see plates 4, 5, and 6.

28. Hydraulic design.--The diversion channel acts as an interceptor for flows from the Cave Creek drainage area. The flow would enter the channel at an angle of 30 degrees. The channel is designed for discharges ranging from 2,000 cubic feet per second at the upstream end to 13,400 cubic feet per second at the downstream end. These values correspond to a flood having a frequency of occurrence once in 100 years. The water-surface profile was determined by the reach method, except at points where large concentrations of side flow would enter; depths were determined by assuming equal momentum at these points. The friction losses were based on a value of "n" of .014 in the Manning formula. Flow in the channel upstream from Cave Creek would be in the undulating stage due to a large inflow over the side of the channel. Flow downstream from Cave Creek confluence would have supercritical velocity. Velocities in the channel would range from 8 to 30 feet per second and depths would range from 6 to 15 feet. A minimum freeboard of 2.5 feet is provided.

29. Geology and soils.--The foundation materials along the proposed channel are Recent alluvium. In the reach across Cave Creek, the materials would be mostly sand and gravel. Outside the Cave Creek reach, the predominant material would be silty sand. The materials could be easily excavated with ordinary earthmoving equipment. Excavation and fill slopes of 1 vertical on 2 horizontal would be stable. Ground water in 1946 was at depths ranging from 100 to 200 feet; hence, a subdrainage system would not be required for the lined channel.

Dreamy Draw Detention Basin

30. Recommended plan.--The detention basin would be constructed in Dreamy Draw on the south side of Shea Boulevard and east of 16th Street. The improvement would consist of an earthfill embankment, an ungated outlet, two saddle dikes along Shea Boulevard, and a detached spillway on the left abutment. The embankment would have a crest length of 480 feet, a top width of 20 feet, a height above streambed of 50 feet, and side slopes of 1 vertical on 2½ horizontal on the upstream side and 1 on 2 on the downstream side. The outlet would consist of a 36-inch-diameter reinforced-concrete conduit with an ungated pool-drain structure.

31. Hydraulic design.--The area-capacity curve for the Dreamy Draw detention basin was determined by use of a contour map with intervals of 10 feet. The net-capacity curve was determined by deducting the sediment volume. The outlet was predicated on voiding the reservoir within 1 week; because the outlet conduit is only 3 feet in diameter and could be rendered inoperative, no consideration was given toward reduction of the reservoir-design flood. The spillway crest was set by storing the volume of the reservoir-design flood plus the 100-year sediment volume. The spillway-design flood was routed by approved standard procedures, assuming the reservoir filled to the spillway crest at the beginning of the flood. Outlet and spillway discharges and flood-routing curves are shown on figures 5 and 6. Freeboard of 5 feet was selected after the effect of wind setup plus rideup and wave heights gave a figure less than the selected 5-foot minimum.

32. Pertinent data.--Pertinent data on the Dreamy Draw detention basin are given in the following table:

Drainage area and design values

Drainage area	sq. miles	1.3
Reservoir-design flood:		
Peak inflow	c.f.s.	2,180
Volume	acre-ft.	300
Spillway-design flood:		
Peak inflow	c.f.s.	9,700
Volume	acre-ft.	1,330
Sediment-storage requirement (100-yr. period)	acre-ft.	150

General

Reservoir:		
Area	acre	30
Capacity	acre-ft.	450
Embankment:		
Top elevation	ft., m.s.l.	1,420
Maximum height	ft.	50
Length	ft.	2,350
Freeboard	ft.	5.0
Spillway:		
Crest elevation	ft., m.s.l.	1,410
Pool-drain conduit:		
Capacity	c.f.s.	100
Diameter	in.	36

33. Geology and soils.--The embankment, dikes, collecting levee, and spillway would be founded on bedrock. The rock is moderately soft to moderately hard schist. Most of the overburden in the streambed has been removed by gravel-pit operations. Hence, all the fill material would be obtained from surplus excavation for the Arizona Canal channel; material from the channel would be chiefly silty sand. Prior to placement of fill, all the existing overburden would be removed; and the fill would be placed directly on the rock. Fill slopes of 1 on $2\frac{1}{2}$ upstream and 1 on 2 downstream would be safe. Underseepage would not be a problem due to the low permeability of the rock foundation. Throughseepage would be controlled by the pervious chimney and downstream drain.

Arizona Canal Diversion Channel and Dreamy Draw Channel

34. Recommended plan.--The Arizona Canal diversion channel would collect floodwaters from the Cave Creek drainage area

between Union Hills Drive and Arizona Canal and from the Dreamy Draw drainage area. The diversion channel would connect with the downstream end of the Dreamy Draw channel east of Seventh Street, thence along the north bank of the Arizona Canal to Skunk Creek, a distance of about 13 miles. Dreamy Draw, the only improved channel intercepted by the diversion channel, would be a concrete-lined channel with a rectangular section 10 feet wide and $3\frac{1}{2}$ miles in length. The construction of six street crossings would be required. The Arizona Canal diversion channel east of Central Avenue would be entrenched in the ground and would be concrete lined with a rectangular cross section ranging in width from 10 to 50 feet. West of Central Avenue, the channel would be unlined with a trapezoidal cross section having side slopes of 1 vertical on $2\frac{1}{4}$ horizontal. Base width would range from 20 to 200 feet, and wall heights would range from 8 to 20 feet. The side slopes would be revetted with 15 inches of stone underlain by 6 inches of gravel filter. The revetment would extend from the top of the side slope to 8 feet below the invert. The stone would be grouted at points of concentrated inflow. A concrete structure would be provided at the confluence with Skunk Creek. Berms along the channel would be paved with asphalt. Construction of nine bridges would be required. The channel details are shown on plates 8, 9, 10, 11, and 12.

35. Hydraulic design.--The diversion channel along the Arizona Canal acts as an interceptor. Flow enters the channel nearly at right angles. The channel along Dreamy Draw would carry the discharge from Dreamy Draw detention basin and provide capacity for the 100-year flood for the area between the detention basin and the Arizona Canal. The channel capacity would range from 100 to 1,500 cubic feet per second. The Arizona Canal diversion channel would be designed for a discharge ranging from 1,500 to 18,500 cubic feet per second, which is equal to a flood having a probability of occurrence of once in 100 years. The water-surface profile was determined by the reach method with friction losses computed by use of the Manning formula. A value of "n" of .014 was assumed in all concrete portions to determine the maximum velocity; in the unlined portion, a value of "n" of .02 was assumed, giving a maximum velocity of 8 feet per second. To determine the maximum depth in the unlined portion, a value of "n" of .03 was assumed. Depth of flow would range from 13 to 16 feet. The minimum freeboard would be 2.5 feet for the trapezoidal section and 2 feet for the rectangular section.

36. Downstream terminus.--Several methods were tried in the junction with the Skunk Creek channel improvement, the most practicable being a concrete transition (base width, 125 to 30 feet) on a relatively steep slope to increase the velocity and decrease the base width. The transition would be perpendicular to the Arizona Canal (acting as a side-channel spillway) and parallel to Skunk Creek at the confluence. This method gives relative velocity and depths in both the transition and Skunk Creek that are compatible.

37. Geology and soils.--The foundation materials along the proposed channel would be Recent alluvium consisting mostly of silty sand. The materials could be easily excavated with ordinary earth-moving equipment. Excavation and fill slopes of 1 on 2 would be stable. Due to the close proximity of the Arizona Canal, perched ground water may be encountered in the excavation. A subdrainage system would be required for the lined portion of the channel. Grouted and ungrouted revetment would be 150-pound stone, and the filter material would be gravel.

Skunk Creek Channel

38. Recommended plan.--The channel would be constructed along Skunk Creek from the Hedgpeth Hills to the confluence with the New River. The channel would carry floodflows from Skunk Creek, Union Hills diversion channel, and Arizona Canal diversion channel. The concrete-lined channel would be about $6\frac{1}{2}$ miles long, with trapezoidal cross section, side slopes of 1 vertical on $2\frac{1}{4}$ horizontal, base width of 15 to 40 feet, and wall heights of 10 to 23 feet. The base slab would be 10 inches thick and the side-slope slabs would be 8 inches thick. Berms along the channel would be paved with asphalt. Four bridges would be constructed. About 2,000 feet of Union Hills Drive would be relocated. For location and details, see plates 13 and 14. For inlet details, see plate 6.

39. Hydraulic design.--The inlet for the improved channel consists of a concrete-lined transition with wing levees extending to high ground on the left and right banks to train the flow to the transition. Each wing levee is about 1,500 feet long, with an 18-inch stone facing and filter on the upstream side. Union Hills diversion channel enters the Skunk Creek improvement 1,500 feet below the inlet. Downstream from the confluence, the channel alinement follows generally the natural channel to the confluence with the Arizona Canal diversion channel. Downstream from the Arizona Canal to the

New River, the channel base width would be 40 feet, ending in a stone-lined transition that acts as an energy dissipator to reduce velocities entering the New River channel. The design capacity of the channel would range from 24,400 to 41,400 cubic feet per second. Water-surface elevations and friction losses were based on the Manning formula with a value of "n" of .014 in the concrete-lined channel and .040 in the stone-lined energy dissipator. Maximum depth in the concrete channel would be 21 feet; and velocity, 31 feet per second. Exit depth in the grouted-stone energy dissipator at the New River would be 7 feet; and velocity, 15 feet per second.

40. Geology and soils.--The foundation materials along the proposed channel would be Recent alluvium consisting chiefly of sand and gravel. The materials could be easily excavated with ordinary earthmoving equipment. Excavation and fill slopes of 1 on 2 would be stable. Ground water was at a depth of about 100 feet in 1946; hence, a subdrainage system would not be required for the lined reach. Grouted and ungrouted revetment would be 150-pound stone, and the filter material would be gravel.

New River Detention Basin

41. Recommended plan.--The improvement would be located about 11 miles north of Peoria, on the New River at West Wing Mountain. The improvement would consist of an earthfill embankment, an ungated outlet, a saddle dike, and a detached spillway located in a saddle on the left abutment of the dam. The embankment would be 2,700 feet long; and the crest, at elevation 1,474 feet, would be about 80 feet above streambed. The saddle dike would be about 4,900 feet long. The top would be 20 feet wide, the embankment slopes would be 1 vertical on $2\frac{1}{2}$ horizontal and 1 vertical on 2 horizontal on the upstream and downstream sides, respectively. The outlet would consist of a 72-inch-diameter reinforced-concrete conduit, a concrete log rack at the inlet, and a concrete energy-dissipating structure at the outlet. The spillway would be excavated in rock with a crest length of 800 feet and a concrete sill at the crest elevation of 1,458 feet. For location and details, see plate 15.

42. Hydraulic design.--The area-capacity curve, shown on plate 15, was computed on the basis of U.S. Bureau of Reclamation topographic survey (revised) dated May 1, 1946. Reservoir areas were determined at contour intervals of 10 feet, and the gross volume was determined for these intervals.

The net capacity curve was determined by deducting the sediment volume from the gross volume. The outlet would be ungated, with a maximum capacity of 1,000 cubic feet per second. (See discharge curves shown on fig. 7.)

43. The standard project flood was routed by assuming an empty reservoir but with the 100-year sediment distributed to the spillway crest. The maximum water surface attained from this routing was used to establish the elevation of the spillway crest. The spillway-design flood (maximum probable) was routed by assuming the reservoir-design flood (standard project) had preceded the maximum probable flood by about 26 hours.

44. A graph showing the relationship between inflow-outflow and reservoir water surface is shown on figure 8. The freeboard was predicated on wave height, rideup, and setup above the water surface obtained by the spillway-design routing. A minimum freeboard of 5.5 feet was selected although the computation showed 4.3 feet would be sufficient.

45. Pertinent data.--Pertinent data on the New River detention basin are given in the following table:

Drainage area and design values

Drainage area	sq. miles	170.0
Reservoir-design flood:		
Peak inflow	c.f.s.	60,000
Volume	acre-ft.	33,700
Spillway-design flood:		
Peak inflow	c.f.s.	128,000
Volume	acre-ft.	87,000
Sediment-storage requirement (100-yr. period)	acre-ft.	10,000

General

Reservoir:		
Area	acre	1,740
Capacity	acre-ft.	39,500
Embankment:		
Top elevation	ft., m.s.l.	1,474
Maximum height	ft.	80
Length	ft.	2,860
Freeboard	ft.	5.5
Spillway:		
Crest elevation	ft., m.s.l.	1,458
Pool-drain conduit:		
Capacity	c.f.s.	1,000
Diameter	in.	72

46. Geology and soils.--A field reconnaissance was made by a team of geologists and soil mechanics engineers. Observations of the conditions at the site indicate that construction of an embankment at the proposed site is feasible. Pertinent information on geology and soils at the site of the New River detention basin is given in following subparagraphs.

(a) Foundation conditions.--The bedrock forming the right abutment is basalt that is overlain by an undefined thickness of loose volcanic rock and boulders. The material across the valley bottom is Recent alluvium consisting of silt, sand, gravel, and cobbles, with a maximum diameter of about 12 inches. The bedrock forming the left abutment and spillway area is granite that is overlain by an undefined thickness of talus. The depth to ground water is unknown, but it is probably at a depth of 50 feet or more.

(b) Design applications.--Borrow materials for the embankment would be obtained from the valley bottom immediately upstream from the embankment. Pervious material could be obtained by processing the streambed material. The same embankment section would be used at this site as proposed for the Adobe damsite. Refinements of details will be made after explorations have been completed. The outlet would be founded on rock at the toe of the right abutment, and the spillway would be notched into rock of the left abutment.

New and Agua Fria Rivers Channelization

47. Recommended plan.--The New River would be improved from Skunk Creek to the confluence with the Agua Fria River, a distance of about 8 miles. Channelization would continue on the Agua Fria River to its junction with the flood plain of the Gila River, a distance of about $7\frac{1}{2}$ miles. The channelization upstream of U.S. Highway No. 60 would consist of excavating an unlined channel and construction of a levee on the east bank and on the west bank only in the vicinity of Atchison, Topeka and Santa Fe railroad and U.S. Highway No. 60 bridges.

48. Upstream from U.S. Highway No. 60, the channel would have a base width of 700 feet except through the Atchison, Topeka and Santa Fe railroad and U.S. Highway No. 60 bridges where it would have a base width of 400 feet. The streamside of the levee would be revetted with 18 inches of stone underlain by 6 inches of gravel filter. The revetment would extend from the top of the levee to 5 feet below the channel invert. On the landside of the east-bank levee, a small drainage ditch would be lined with stone to a height of 5 feet. Through the

bridges, the channel invert would be protected with stone. Side drainage would enter the channel by culverts passing through the levees. Relocations would consist of modifying the railroad and U.S. Highway No. 60 bridges, construction of a dip crossing at Thunderbird Avenue, and of protecting utilities in place or moving them clear of construction.

49. Downstream from U.S. Highway No. 60, the channel would have a bottom width varying from 800 to 1,500 feet, be entrenched in the ground, and have a levee only in the vicinity of Avondale. Grouted stone would be provided at the confluence of the New and the Agua Fria Rivers. Dip crossings would be provided at Peoria and Olive Avenues; Indian School, Thomas, and McDowell Roads; and at Van Buren Street. About one-half mile of El Mirage Road would be relocated, and a bridge modification would be required at Glendale Boulevard. The existing Southern Pacific railroad and U.S. Highway No. 80 bridges would be utilized, and the existing dip crossing for the eastbound highway traffic would be lowered. Utilities would be relocated as required. The alinement and details are shown on plates 16, 17, 18, 19, and 20.

50. Hydraulic design.--The New and the Agua Fria Rivers channelization and levee upstream from U.S. Highway No. 60 were based on the 100-year frequency discharge with Adobe, Cave Buttes, and the New River detention basins constructed. Flow would have subcritical velocity with control sections at the Atchison, Topeka and Santa Fe railroad and U.S. Highway No. 60 bridges. These bridges would require modifications to the extent of four additional spans for the railroad bridge and two additional spans for the highway bridge.

51. Water-surface computations upstream of U.S. Highway No. 60 were made by the reach method, with friction losses based on a value of "n" of .035 in the Manning formula. Freeboard of 3 feet would be provided. The maximum depth would be 13.0 feet; and the velocity, 11.5 feet per second.

52. The channel would be excavated to have sufficient capacity to contain the 100-year design flood (53,400 c.f.s.). The levee on the left bank would prevent the design flood from overflowing to the east. The training levees on the right bank would channelize the flow through the bridges.

53. The improvement downstream of U.S. Highway No. 60 continues along the New and the Agua Fria Rivers to 9,000 feet downstream of U.S. Highway No. 80 at Avondale, with a design capacity ranging from 53,400 to 74,000 cubic feet per second.

The outlet would be protected from scour by dumped stone. The maximum depth is 9 feet; and the velocity, 14 feet per second. The water-surface profile was determined by computing the water surface based on an "n" value of .025 in the Manning formula.

54. Geology and soils.--The foundation materials along the proposed channels would be Recent alluvium consisting of silt, sand, and gravel. The materials could be easily excavated with ordinary earthmoving equipment. Excavation and fill slopes of 1 on 2 would be stable. Ground water was at a depth of about 100 feet below the ground surface in 1946. Ungrouted revetment would be 150-pound stone and would be underlain by a gravel filter. Grouted revetment would also be 150-pound stone but would not be underlain by a filter.

55. Diversion and control of water.--Control of runoff would be accomplished by controlled construction. Closure of embankment for the detention basins would be accomplished after completion of the outlet so that it could be used as a diversion facility. The diversion channels would be constructed starting at their lower ends to prevent problems resulting from the diversion of water. The improvement of existing channels would be done in periods of least rainfall expectancy. In case of flow in the New River or the Agua Fria River, water would be diverted to either side of the channel until work was completed on one-half the channel; the flow would then be channeled into the completed part.

56. Rights-of-way.--Permanent rights-of-way would be required for the detention basins, channels, and levees. Permanent easements would be required for floodway and to restrict excavation in the New River and the Agua Fria River. A floodway easement would be required downstream of construction on the Agua Fria River to about midchannel of the Gila River. Temporary easements during construction would be necessary on each side of the channels for the contractor work area. Additional temporary easements would be required for disposal areas along the diversion channels, Skunk Creek, and for fill along the lower Agua Fria River.

U.S. ARMY ENGINEER DISTRICT

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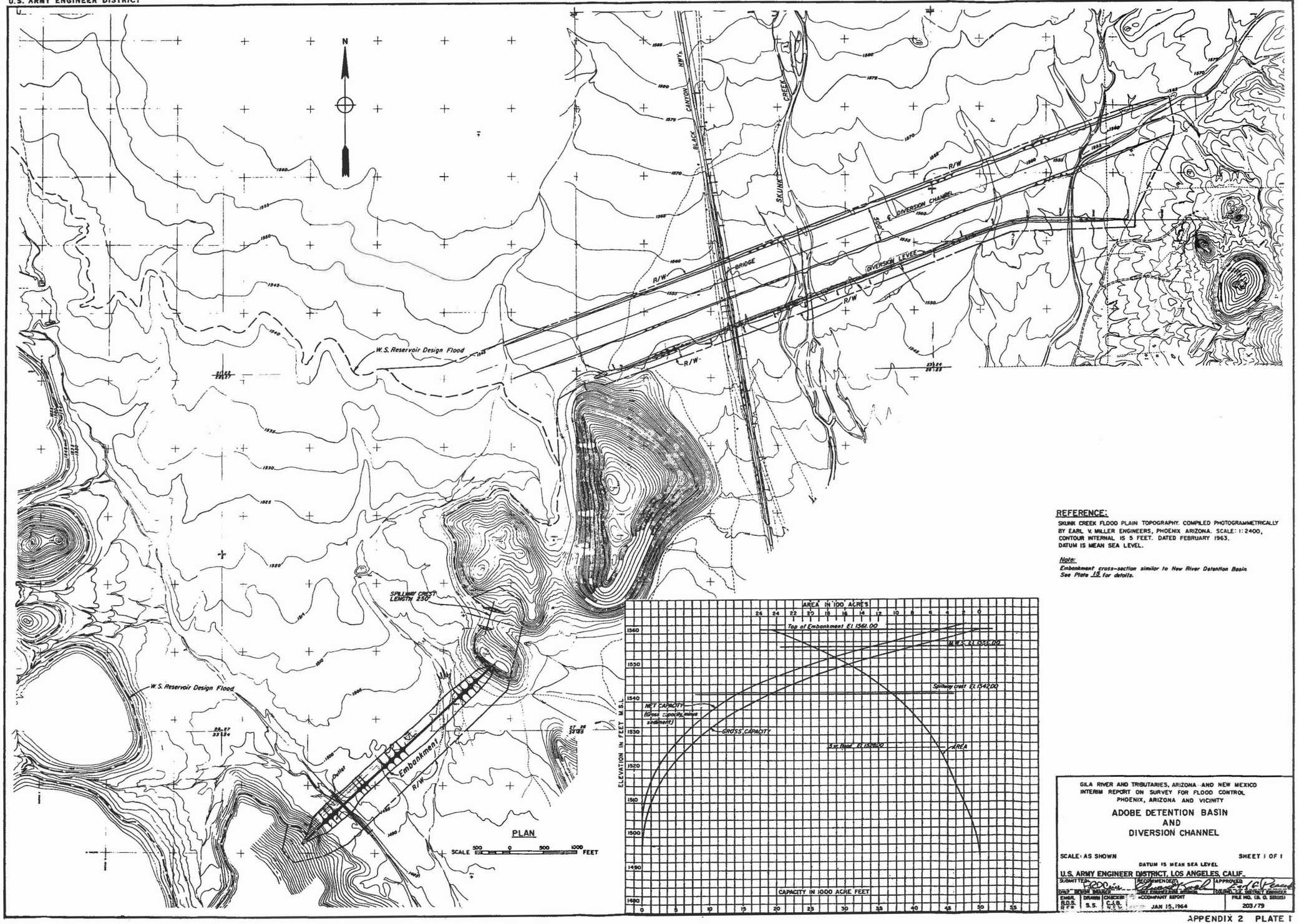


REFERENCE:

SKUNK CREEK FLOOD PLAIN TOPOGRAPHY. COMPILED PHOTOGRAMMETRICALLY BY EARL V. MILLER ENGINEERS, PHOENIX ARIZONA. SCALE: 1:2400, CONTOUR INTERNAL IS 5 FEET. DATED FEBRUARY 1963. DATUM IS MEAN SEA LEVEL.

Note:

Embankment cross-section similar to New River Detention Basin. See Plate 12 for details.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

ADOBE DETENTION BASIN AND DIVERSION CHANNEL

SCALE: AS SHOWN

SHEET 1 OF 1

DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED	RECOMMENDED	APPROVED
Chief, Design Branch	Chief, Engineering Division	Colonel, C.E. District Engineer

ENGR. R.O.S.	DRAWN	CHECKED	COMPANY REPORT	FILE NO. (D. O. SERIES)
	S.S.	C.A.B.	JAN 15, 1964	203/79

APPENDIX 2 PLATE 1

T.T.1

El. 1530±

	Cobbles and boulders in matrix of sand and silt, coarse material remanent of volcanic cap rock (Basalt) non cemented. Average diameter 1'+, maximum 3', cobbles < 20% by volume.
4.0'	Tuffaceous agglomerate reddish brown, moderately weathered, poorly cemented, coarse fractions generally less than 1/2" sub-angular fragments of a variety of rock.
8.0'	Tuffaceous agglomerate, similar to above except moderately cemented and slight increase in coarse material, moderately calcareous.
11.0'	Tuffaceous agglomerate, reddish brown to buff with occasional cobbles and small boulders (volcanic) in a calcareous silty sand matrix, locally nearly white calcareous. Tuffaceous zones, generally becoming more dense and cemented with depth.
14.0'	

Easy ripping 4'to 10', moderately hard ripping 10'to 14'.

T.T.2

El. 1512±

	Sandy silt, brown, dry to slightly damp, occasional cobbles near ground surface moderately dense.
3.0'	Sandy silt, with occasional small cobbles and <.5% fine gravel, light brown, slightly damp, dense, calcareous.
10.0'	Tuffaceous agglomerate, pinkish buff, moderately weathered, moderate to well cemented, small cobbles and gravel in calcareous silty sand matrix.
12.0'	

Ripping required below 3' because of cobbles and boulders in bottom of trench very difficult rock probably gradational between volcanic cap (basalt boulders) and underlying weathered agglomerate. Ripped 2' below trench bottom.

T.T.3

El. 1541±

1.0'	Silt with a few cobbles and small boulders, brown, dry.
2.5'	Caliche, light buff, well cemented, moderately hard to hard.
5.0'	Silty sand, buff brown sand, medium to coarse grained sub-angular to angular moderately cemented with caliche.
12.0'	Tuffaceous agglomerate, light buff brown, moderately weathered and decomposed, moderately cemented with calcium carbonate, 10-15% gravel and occasional small cobbles in silty sand matrix, local zones of poorly cemented materials.

Ripping required below 1', very difficult ripping from 1 to 2.5' in caliche zone, Ripped 2' below trench bottom.

T.T.4

El. 1496±

	Silty clay, brown, dry to slightly damp.
2.0'	Silty gravelly sand with 10-15% sub-rdd. cobbles and occasional boulders up to 2 1/2' diameter. Sand well-graded 35%±, by vol. Silt 25%, gravel 15%, brown to buff, slight to moderately cemented depending on caliche horizons, dense.
9.0'	

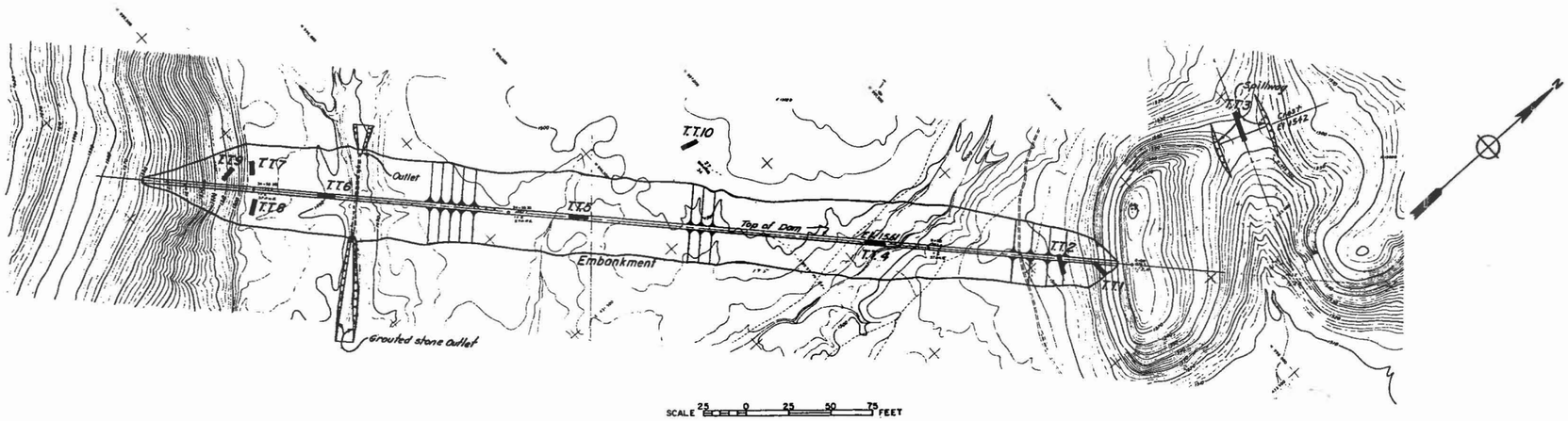
Using ripper below 2' because of cobbles and boulders in cemented matrix.

T.T.5

El. 1497±

1.0'	Sandy silt with gravel and occasional cobbles and small boulders, brown, dry.
	Clay, brown, slightly damp, firm to hard, slightly silty.
4.0'	Gravelly sandy silt with cobbles and occasional boulders up to 1 1/2' diameter light brown to buff, silt 30%, sand 20%, gravel 20%, cobbles 15%, very little moisture (<1%), few thin caliche zones, moderate to poorly cemented.
9.0'	

Using ripper below 4' because of cobbles and boulders; material becoming more dense and cemented with depth.



SCALE 25 0 25 50 75 FEET

T.T.6

El. 1490±

	Silt, brown, dry to slightly damp at 2' moderately dense, <5% fine sand, slightly calcareous.
4.0'	Silty sand, brown, slightly damp, dense occasional fine gravel and small cobbles, sand well-graded 80%± by vol.
7.0'	Silty sand with 15-20% cobbles and small boulders, dense, poorly cemented, sand well-graded 35%± by vol.
9.0'	

Using ripper in coarse material in bottom half of trench.

T.T.7

El. 1493±

	Silty sand, with occasional small cobbles, dry, moderately dense, sand well-graded, 60%± by vol.
6.0'	Silt, buff brown, dry, dense, calcareous (caliche).
9.0'	

Cobbles and boulders in a sandy silt matrix, dense moderately well-cemented.

Ripped 2' below bottom of trench. Ripping required full depth of trench because of cobbles and boulders extending into trench from right abutment and because of cemented nature of material southwest wall of trench a coarse material for full depth.

T.T.8

El. 1493±

	Silt, brown, dry, calcareous, moderately dense.
6.0'	Sand, light brown, well-graded, moderately dense to dense, <5% fine gravel.
8.0'	
8.5	Cobbles and boulders in a silty sand matrix, light brown, calcareous, moderately cemented in bottom of trench.

Ripping required below 5.5' because of coarse material and cementation Cobbles and boulders extend into trench from right abutment below depth of 3.5' in southwest wall. Ripped 2' in bottom of trench.

T.T.9

El. 1510±

3.0'	Cobbles and boulders in sandy silt matrix. Boulders up to 5' dia. Unable to rip below 3' max.

T.T.10

El. 1502±

	Clay, brown, dry to slightly damp, firm.
3.5'	Sandy silt, buff brown slightly cemented very calcareous.
5.5'	Silty sandy gravel with occasional cobbles and a few small boulders, sand 25%, gravel 40% @ 8', cobbles 15%, slightly cemented below 8' buff brown.
8.0'	

Ripping required in coarse material.

LEGEND

T.T.2 — Location and number of test trench

GENERAL NOTES

1. All trenches were excavated in February 1963 with a D-8 caterpillar dozer with a hydraulic ripper. Ripping was required as stated on the logs.
2. Ground water was not encountered.
3. Soil classifications are based on visual examination in accordance with Unified Soil Classification System.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

ADOBE DETENTION BASIN

FOUNDATION EXPLORATION

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED:	RECOMMENDED:	APPROVED:
Chief, Fdn. & Matls. Branch	Chief, Engineering Division	Colonel, C.E., District Engineer

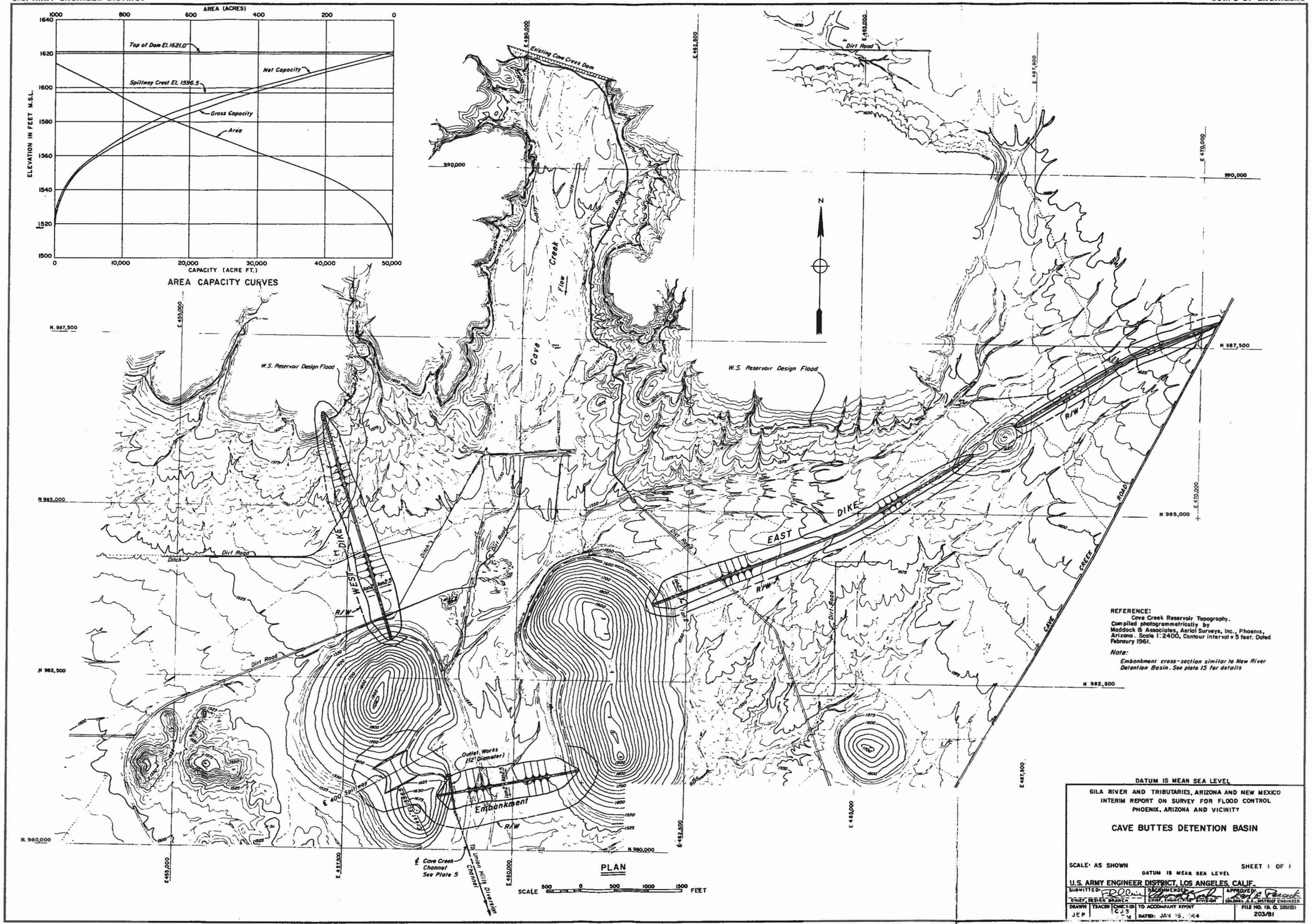
ENGINEER	DRAWN	CHECKED	TO ACCOMPANY REPORT	FILE NO. (To Be Supplied)
C.A.F.		C.A.F.	DATED: JAN 15, 1964	203/80

APPENDIX 2 PLATE 2

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

AREA CAPACITY CURVES



PLAN

REFERENCE:
Cave Creek Reservoir Topography. Compiled photogrammetrically by Maddock & Associates, Aerial Surveys, Inc., Phoenix, Arizona. Scale 1:2400, Contour interval = 5 feet. Dated February 1961.

Note:
Embankment cross-section similar to New River Detention Basin. See plate 15 for details

DATUM IS MEAN SEA LEVEL

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

CAVE BUTTES DETENTION BASIN

SCALE: AS SHOWN

SHEET 1 OF 1

DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

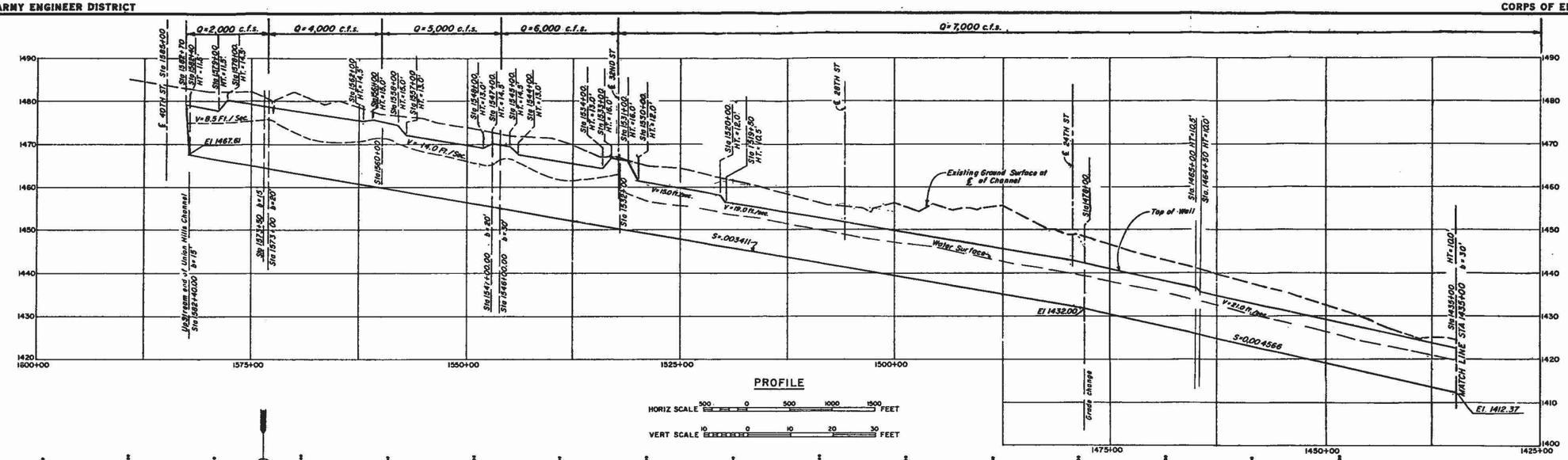
SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, DESIGN BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E., DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. ID. O. SERIES
JEP		CJS	DATED: JAN 15, '64	203/81

APPENDIX 2 PLATE 3

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



PROFILE

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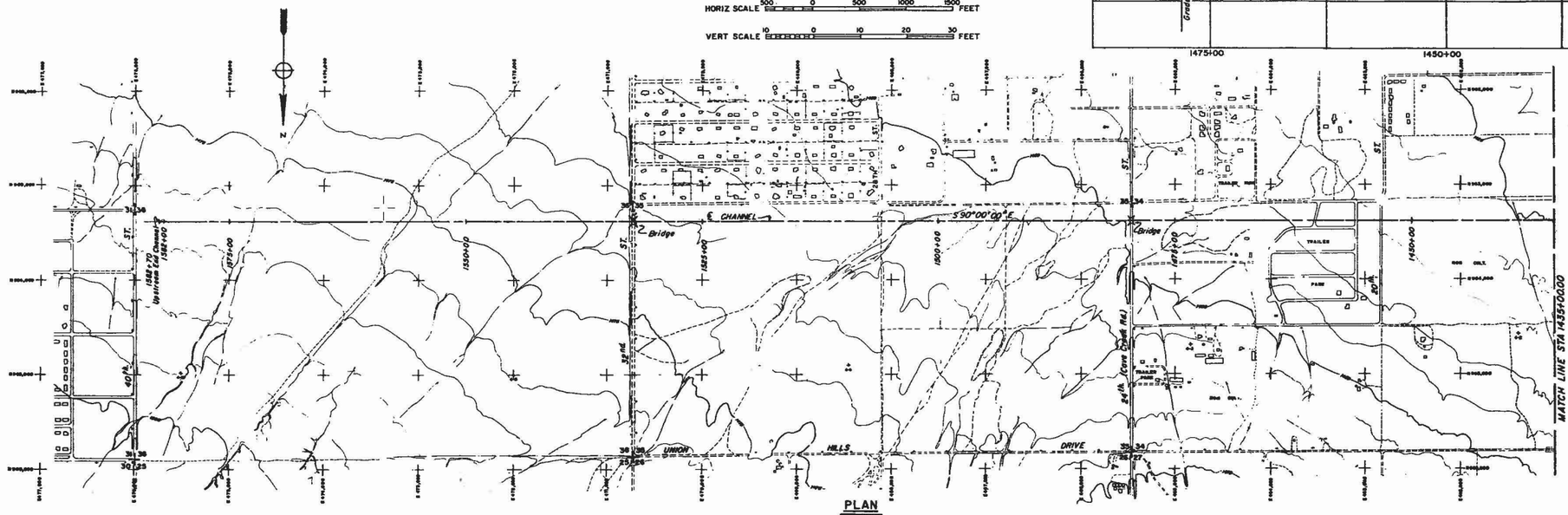
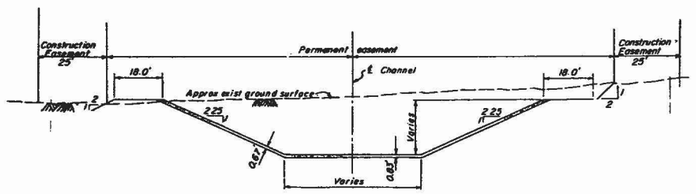
VERT SCALE 10 0 10 20 30 FEET



PLAN

SCALE 500 0 500 1000 1500 FEET



STA 1582+70 TO STA 1079+16.5

CHANNEL SECTION

NOT TO SCALE

REFERENCE:

Topography from maps photogrammetrically prepared by Johannesen and Girard Consulting Engineering, dated January 1963. Scale 1:2400 and contour interval of 5 feet.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

UNION HILLS
DIVERSION CHANNEL

SCALE: AS SHOWN

SHEET 1 OF 3

DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

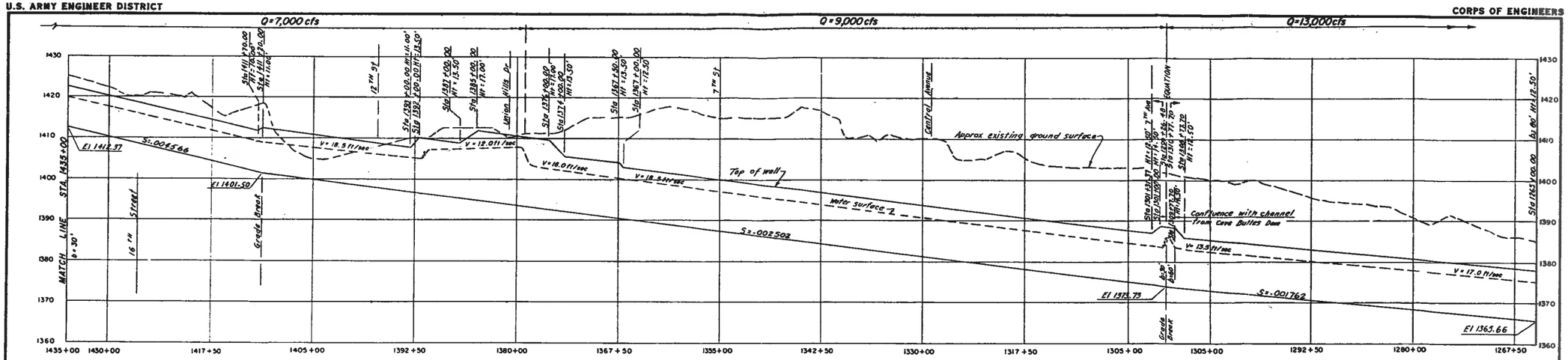
SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, ENGINEERING BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E. DISTRICT ENGINEER

ENGR.	DRAWN	CHECKED	TO ACCOMPANY REPORT	FILE NO. (I.O. SERIES)
R.D.S. R.F.R.	S.O'H.	C.J.B. N.E.M.	DATED: JAN 15, 1964	203/82

APPENDIX 2 PLATE 4

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS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Sta 1398+00.00 M=14.00'
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Sta 1387+00.00 M=13.50'
Sta 1385+00.00 M=17.00'
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Sta 1374+00.00 M=13.50'
Sta 1367+90.00 M=13.50'
Sta 1367+00.00 M=12.50'
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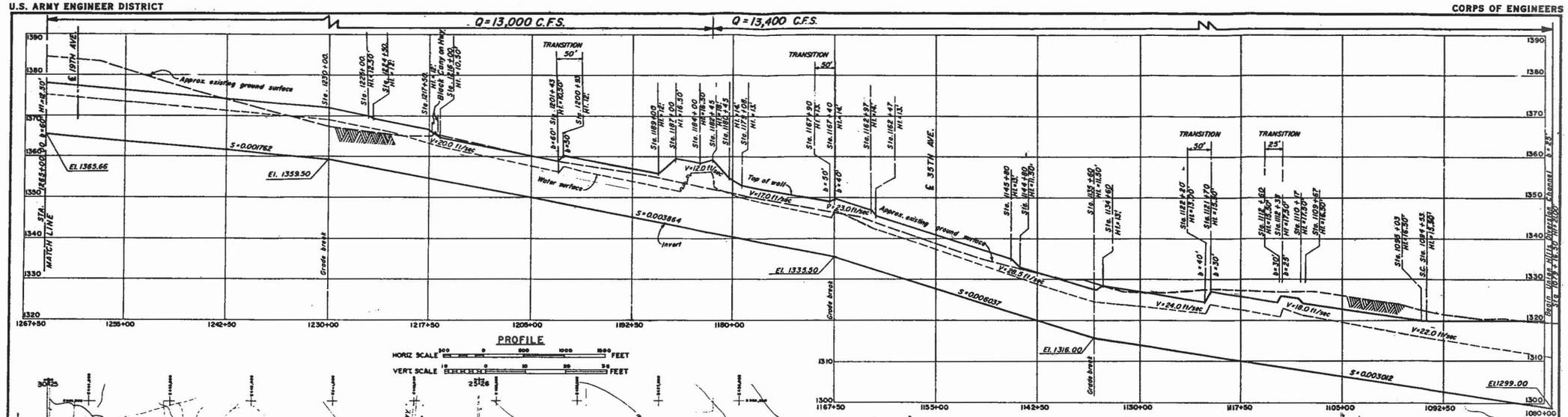
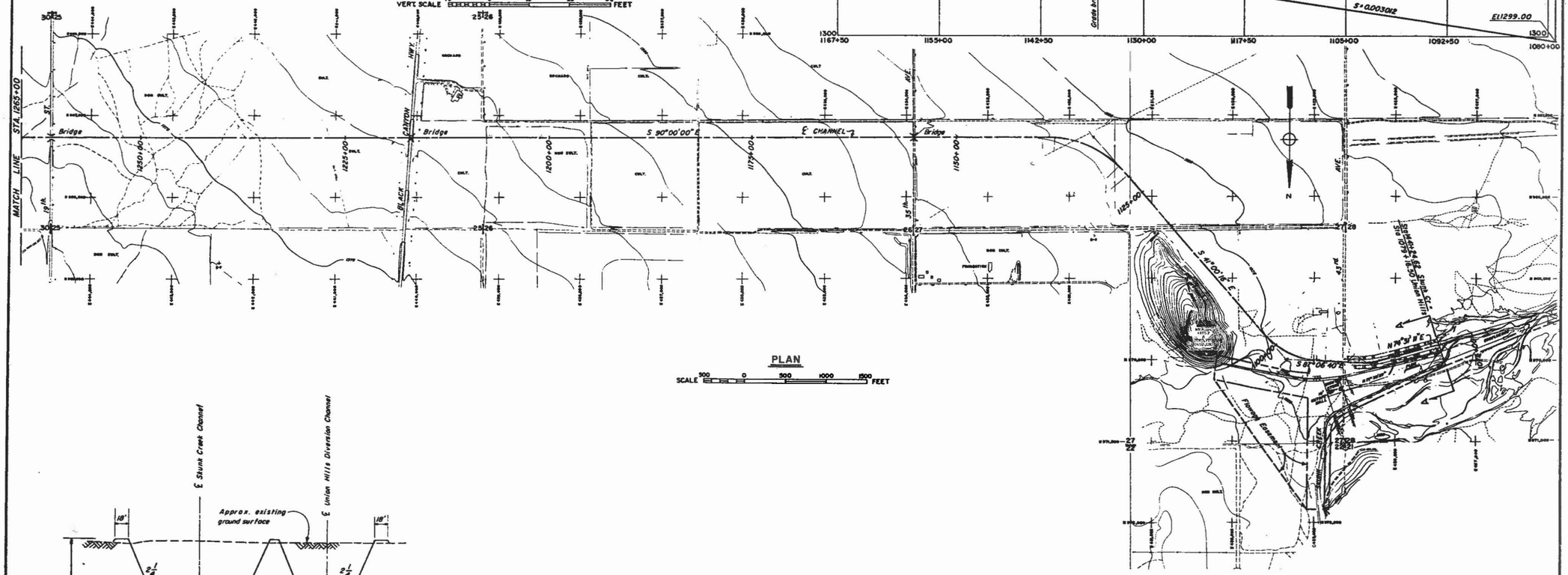
U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS





PLAN

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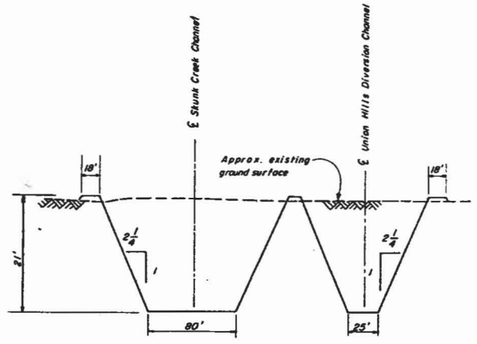


SECTION A-A

NOT TO SCALE

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

UNION HILLS DIVERSION CHANNEL

SCALE: AS SHOWN

DATUM IS MEAN SEA LEVEL

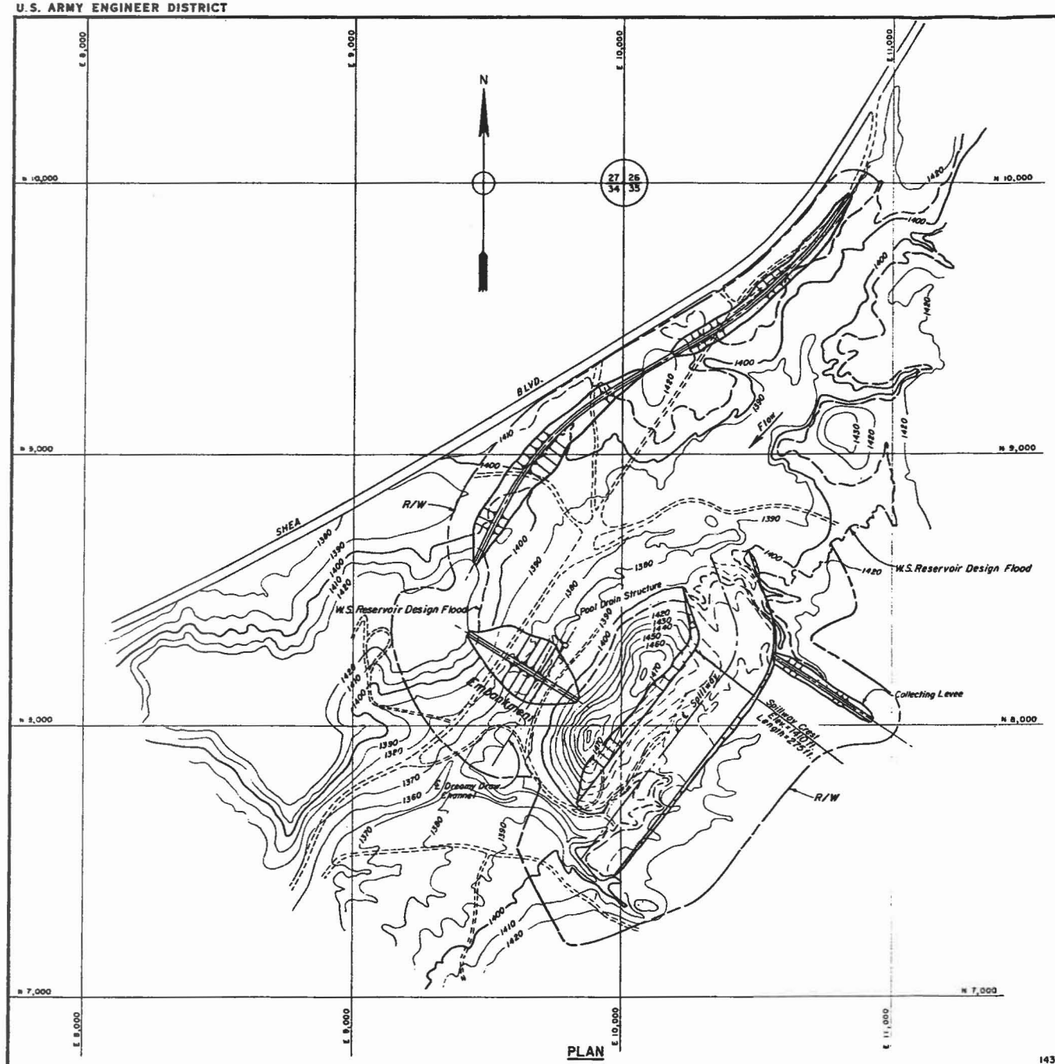
SHEET 3 OF 3

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, ENGR. DIV.	CHIEF, PLANNING DIVISION	COLONEL, C.E. DISTRICT ENGINEER

ENGR. R.D.S. R.E.R.	DRAWN	CHECKED	TO ACCOMPANY REPORT DATED: JAN 15, 1984	FILE NO. (I.O.D. SERIES) 203/84
	L.L.M.	C.L.D. R.E.R.		

APPENDIX 2 PLATE 6



PLAN

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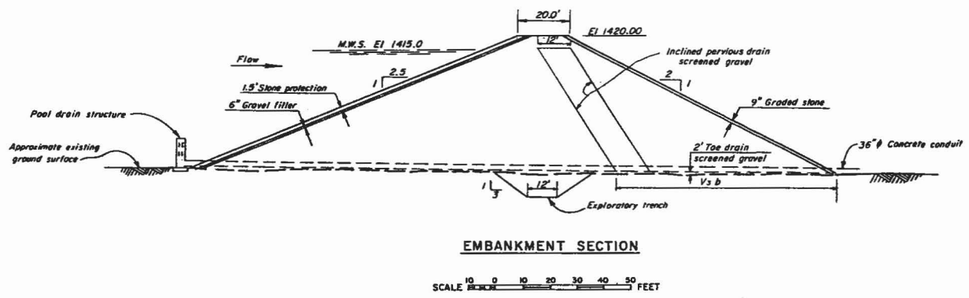

EMBANKMENT SECTION

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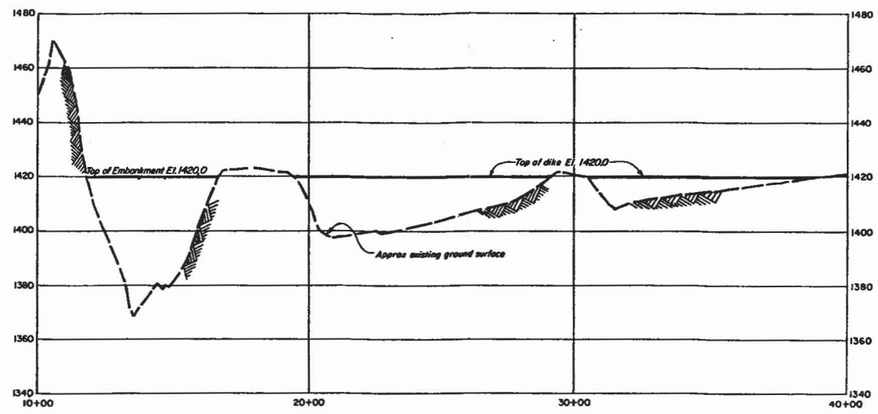
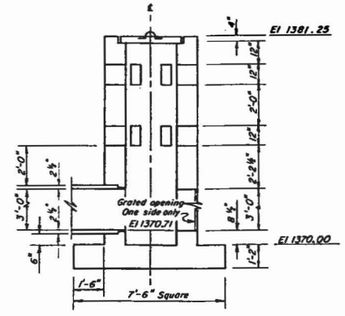


PROFILE OF DAM

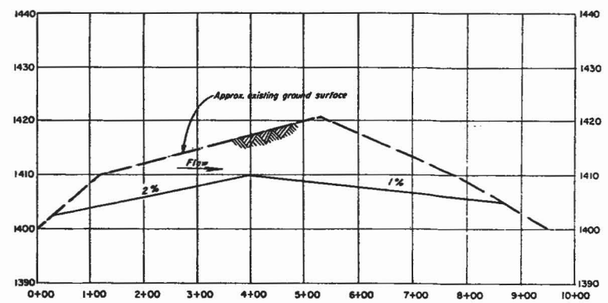
HORIZ SCALE 100 0 100 200 300 400 500 FEET

VERT. SCALE 10 0 10 20 30 40 50 FEET



POOL DRAIN STRUCTURE

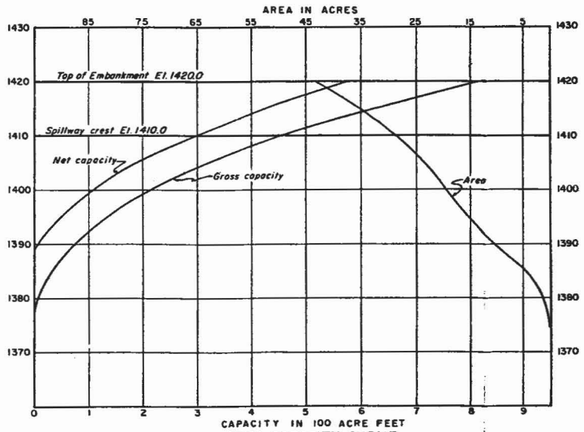
SCALE 1 0 5 10 FEET



PROFILE OF SPILLWAY

HORIZ SCALE 10 0 10 20 30 FEET

VERT. SCALE 100 0 100 200 300 FEET



AREA CAPACITY CURVE

REFERENCE:
TOPOGRAPHY FURNISHED BY, EARLE V. MILLER ENGINEERS, PHOENIX, ARIZONA. DATED JANUARY 1963.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

DREAMY DRAW DETENTION BASIN

SCALE: AS SHOWN

SHEET 1 OF 1

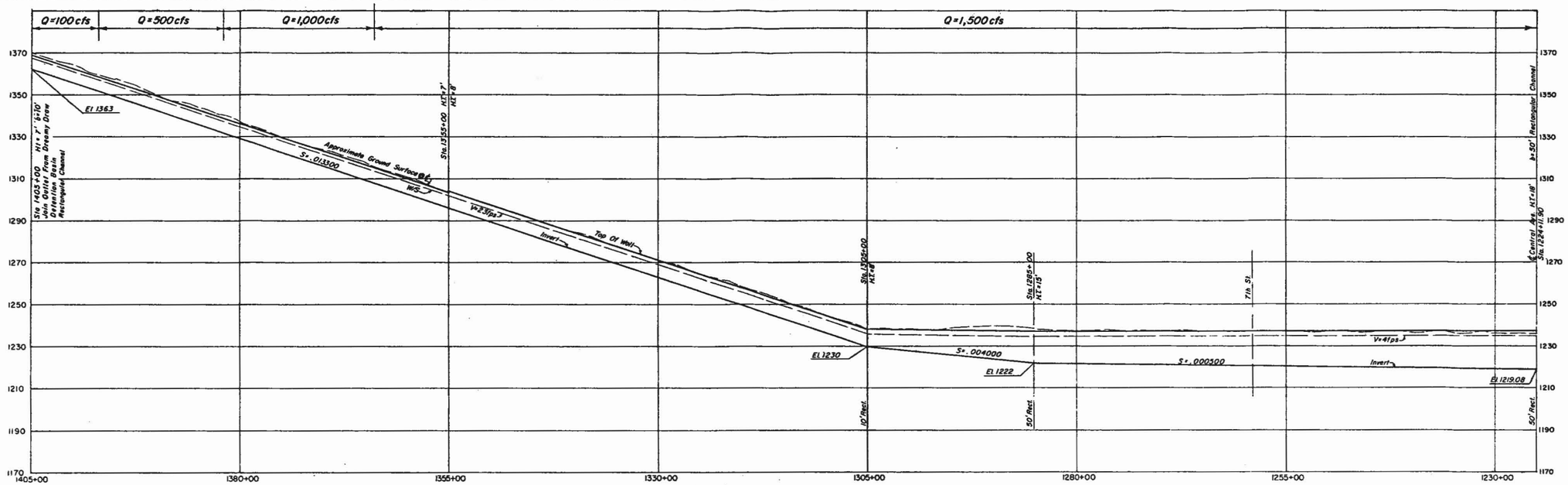
DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, HDRD BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E., DISTRICT ENGINEER

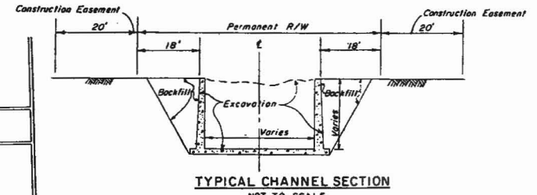
DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. ID. D. SERIES
A.S.		C.J.B. R.E.M.	DATED: JAN 15, 1964	203/85

U.S. ARMY ENGINEER DISTRICT — CORPS OF ENGINEERS



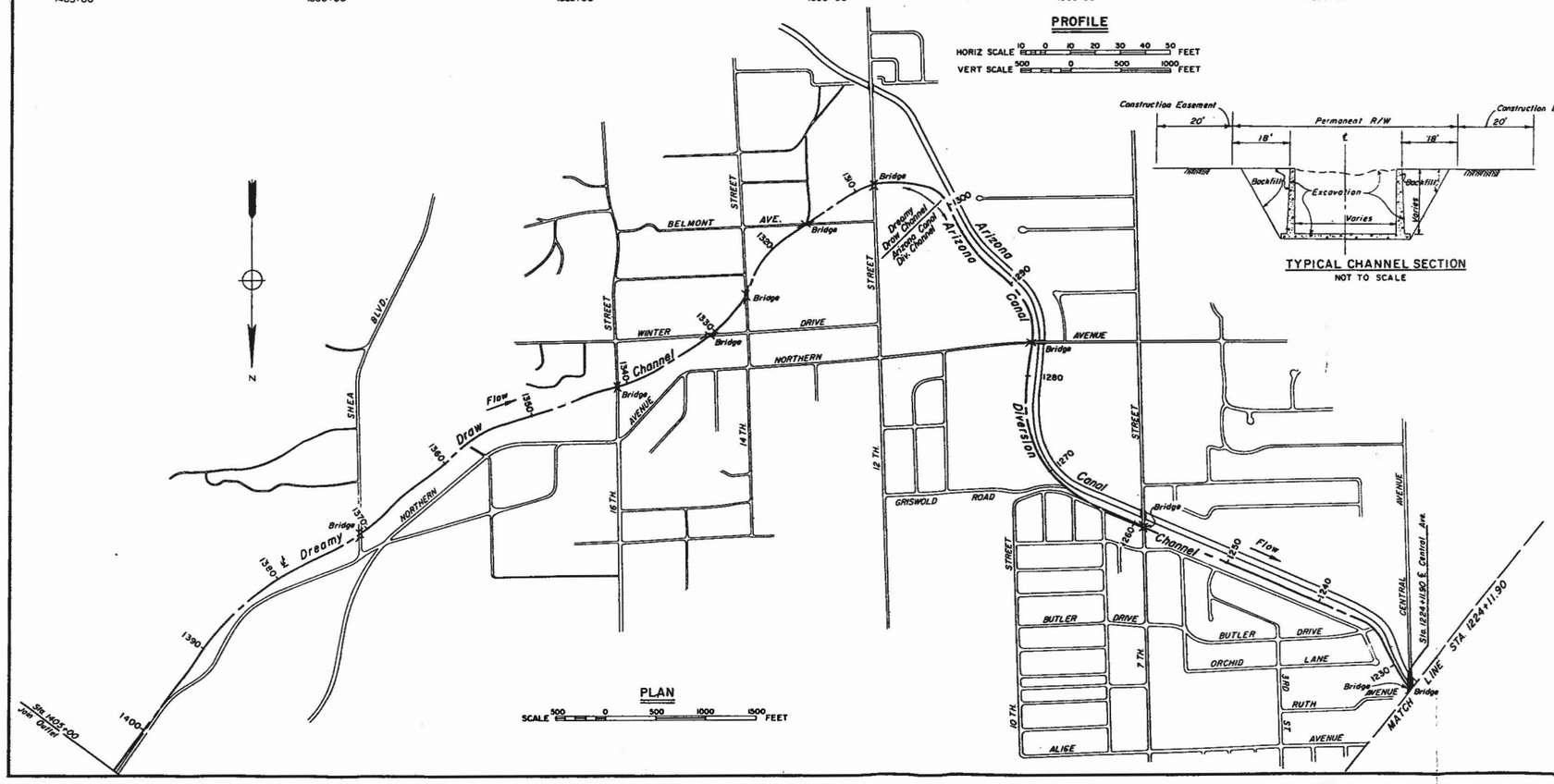
PROFILE

HORIZ SCALE 10 0 10 20 30 40 50 FEET
VERT SCALE 500 0 500 1000 FEET



TYPICAL CHANNEL SECTION

NOT TO SCALE



PLAN

SCALE 500 0 500 1000 1500 FEET

REFERENCE:

PLANIMETRY TAKEN FROM AERIAL PHOTOGRAPHS DATED JANUARY 1958.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

ARIZONA CANAL DIVERSION CHANNEL AND DREAMY DRAW CHANNEL

SCALE: AS SHOWN — SHEET 1 OF 5

DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED: CHIEF, DESIGN BRANCH	RECOMMENDED: CHIEF, ENGINEERING DIVISION	APPROVED: COLONEL, C.E., DISTRICT ENGINEER
DRAWN: J.E.P.	TRACED:	CHECKED: C.I.B. N.E.M.
TO ACCOMPANY REPORT DATED: JAN 15, 1964		FILE NO. (R. O. SERIES) 203/86

APPENDIX 2 PLATE 8

Flood Control District
of
Maricopa County
3325 WEST DURANGO STREET
PHOENIX, ARIZONA 85009

MEMO

FOR: Files

March 14, 1969

FROM: L. E. Ohsiek

SUBJECT: Arizona Canal floodway; Phase B report.

Plate 3 of appendix 2 to the Phase B report contains a typical section of the floodway proposed along the Arizona Canal. This section shows a 30' strip alongside the canal and in addition to the 18' access road on the south side of the floodway. During his recent visit to the District office, Col. Lowry asked what this 30' was intended for, and whether it could be combined with the 18' access road to reduce the amount of right-of-way required.

On March 12, 1969, Mr. Al Gidea of the District office called to explain the purpose of this 30' strip; Mr. Fujiwara was also on the phone. He said this 30' was intended as protection against seepage from the irrigation canal into the deeper floodway. If seepage were to develop, it could cause either uplift to the concrete lining of the floodway or piping action through the embankment with consequent repair and maintenance costs. He recommended that this 30' be retained in addition to the 18' access road until the time for construction approaches. At that time borings and soil investigations can be made to determine whether the design can be modified.

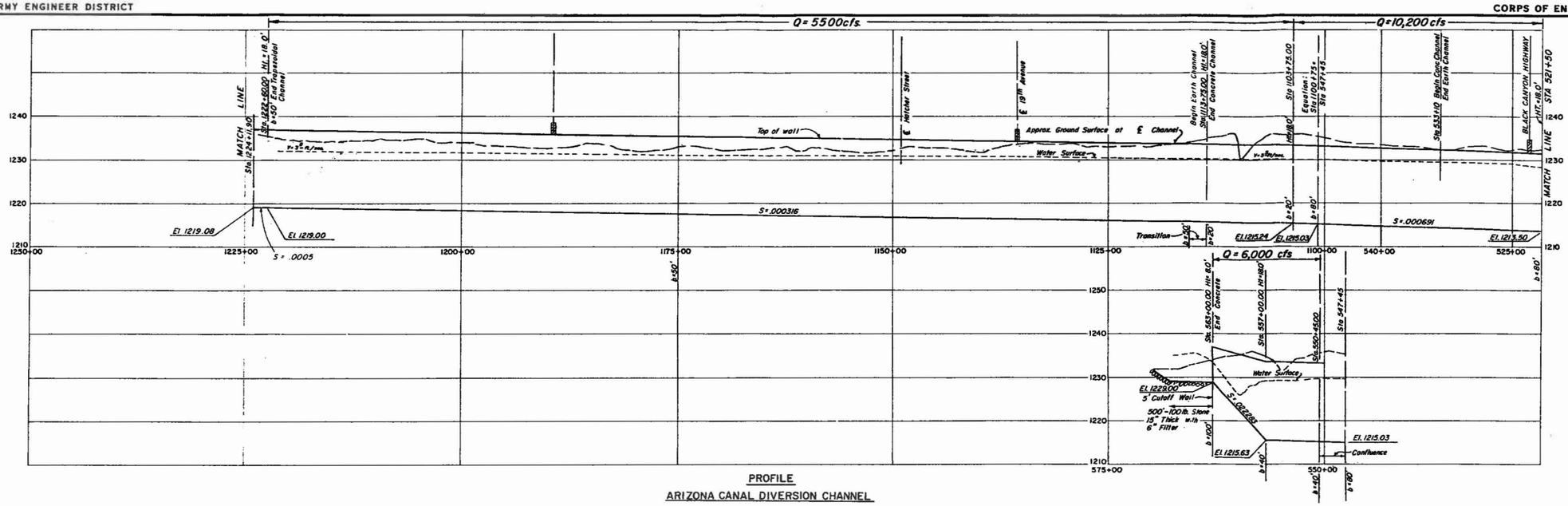
L. E. Ohsiek

L.E. Ohsiek

js

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

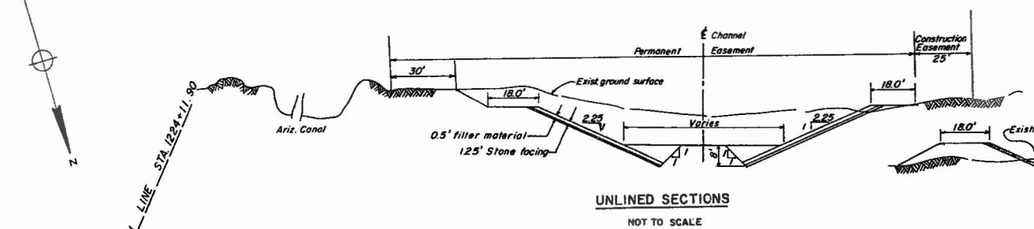


PROFILE
ARIZONA CANAL DIVERSION CHANNEL

HORIZ. SCALE 500 0 500 1000 1500 FEET
VERT. SCALE 10 0 10 20 30 FEET

PROFILE
CAVE CREEK INLET

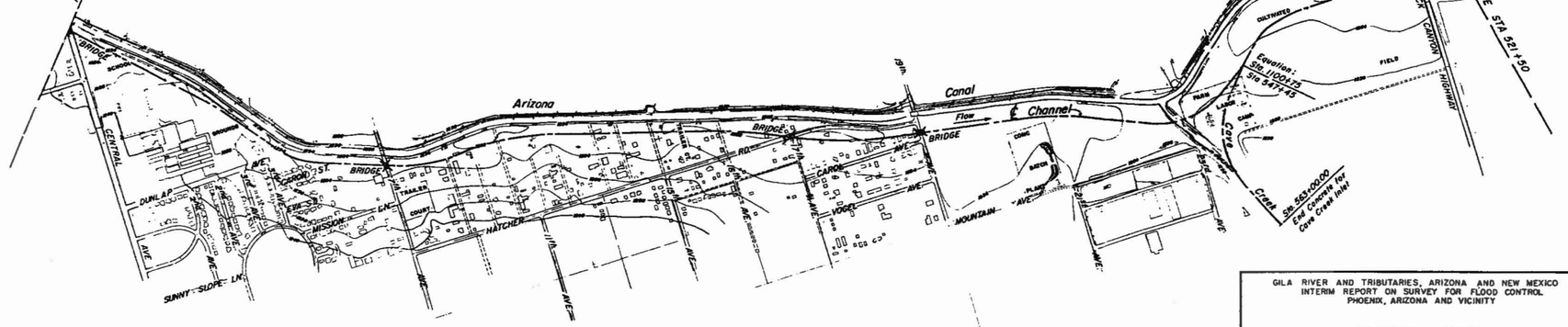
HORIZ. SCALE 500 0 500 1000 1500 FEET
VERT. SCALE 10 0 10 20 30 FEET



UNLINED SECTIONS
NOT TO SCALE

CHANNEL SECTIONS

LINED SECTIONS
NOT TO SCALE



PLAN
SCALE 500 0 500 1000 1500 FEET

REFERENCE:

TOPOGRAPHY COMPILED FROM AERIAL PHOTOGRAPHS BY YOST AND GARDNER ENGINEERS, DATED MAY 1963. SCALE 1:2400 AND CONTOUR INTERVAL = 2FT.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

ARIZONA CANAL DIVERSION CHANNEL

SCALE: AS SHOWN

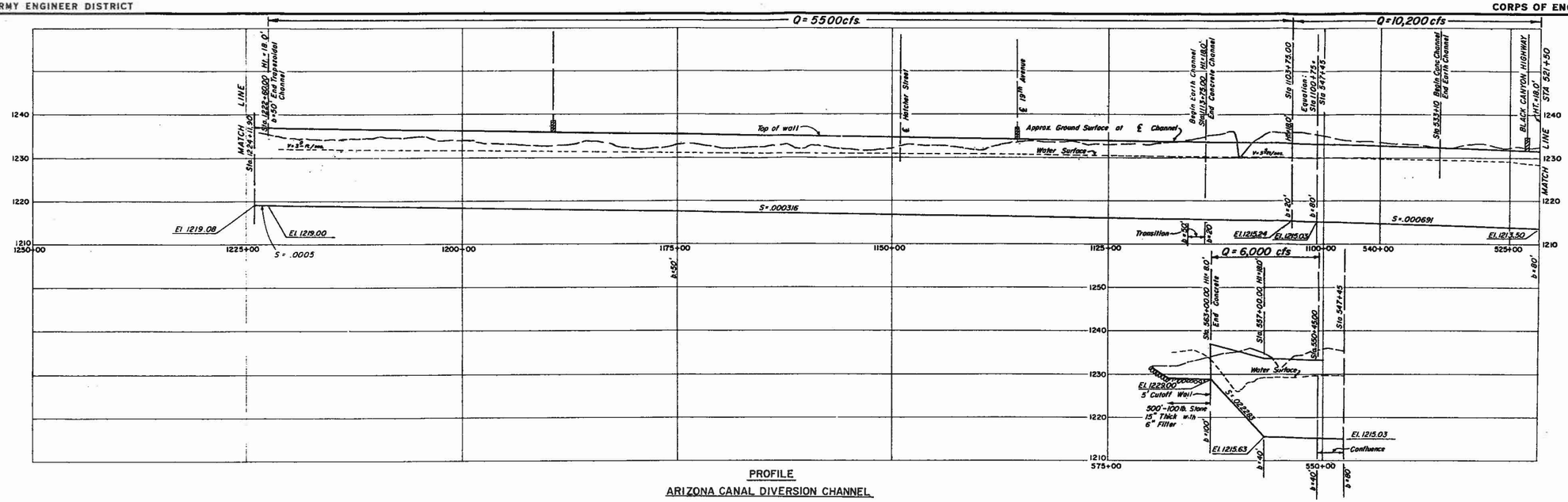
SHEET 2 OF 5

DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, PLANNING BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E. DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (D. O. SERIES)
J.E.P.		C.J.B. N.E.M.	DATED: JAN 15, 1964	203/87

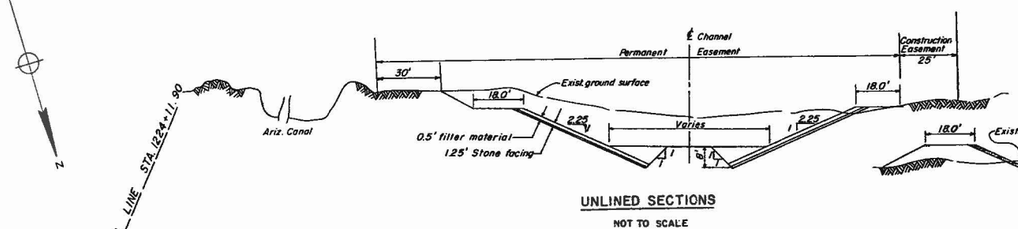


PROFILE
ARIZONA CANAL DIVERSION CHANNEL

HORIZ. SCALE 500 0 500 1000 1500 FEET
VERT. SCALE 10 0 10 20 30 FEET

PROFILE
CAVE CREEK INLET

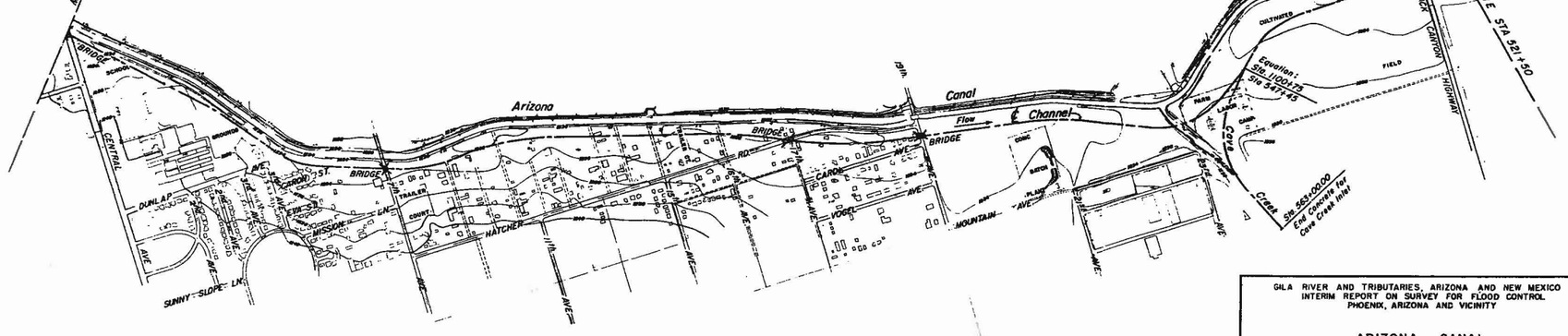
HORIZ. SCALE 500 0 500 1000 1500 FEET
VERT. SCALE 10 0 10 20 30 FEET



UNLINED SECTIONS
NOT TO SCALE

LINED SECTIONS
NOT TO SCALE

CHANNEL SECTIONS



PLAN
SCALE 500 0 500 1000 1500 FEET

REFERENCE:

TOPOGRAPHY COMPILED FROM AERIAL PHOTOGRAPHS BY YOST AND GARDNER ENGINEERS, DATED MAY 1963. SCALE 1:2400 AND CONTOUR INTERVAL = 2FT.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

ARIZONA CANAL
DIVERSION CHANNEL

SCALE: AS SHOWN

SHEET 2 OF 5

DATUM IS MEAN SEA LEVEL

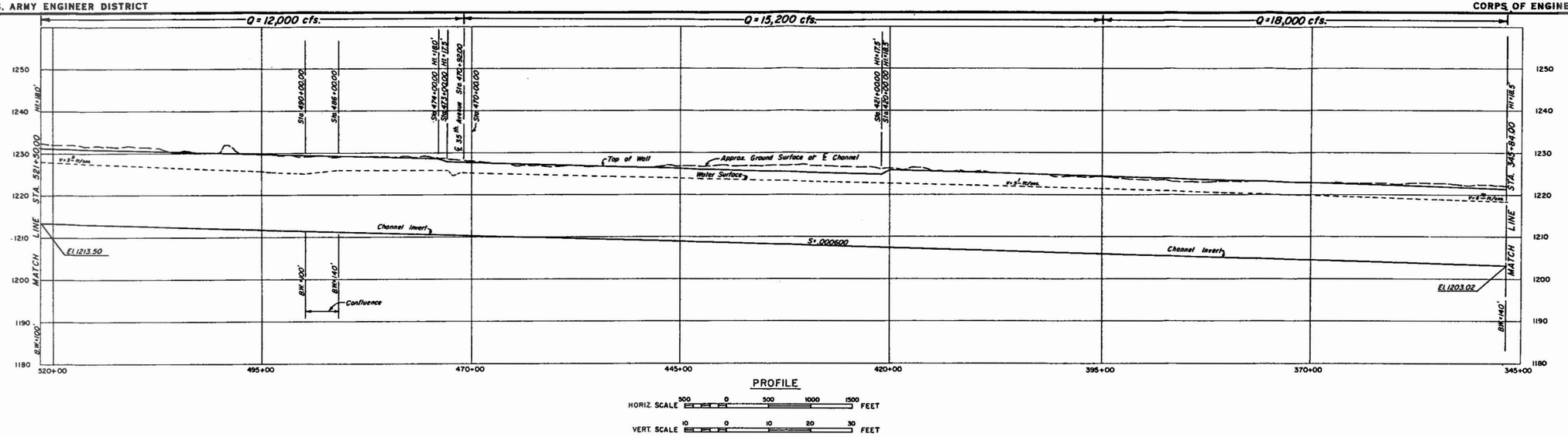
U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, REPORTS BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E. DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (D. O. SERIES)
J.E.P.		C.J.B. N.E.M.	DATED: JAN 15, 1964	203/87

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



PROFILE

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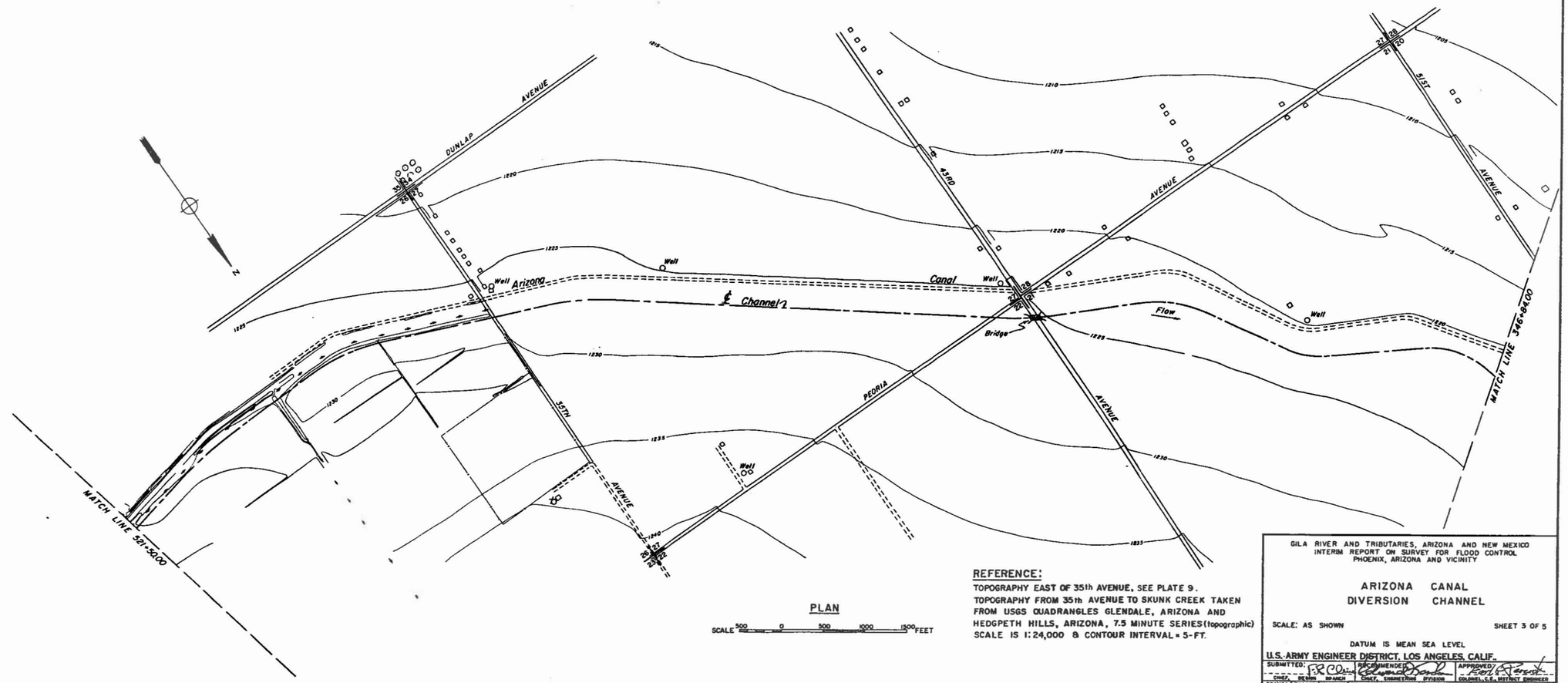
VERT. SCALE 10 0 10 20 30 FEET



PLAN

SCALE 500 0 500 1000 1500 FEET

REFERENCE:

TOPOGRAPHY EAST OF 35th AVENUE, SEE PLATE 9.
TOPOGRAPHY FROM 35th AVENUE TO SKUNK CREEK TAKEN FROM USGS QUADRANGLES GLENDALE, ARIZONA AND HEDGPETH HILLS, ARIZONA, 7.5 MINUTE SERIES (topographic) SCALE IS 1:24,000 & CONTOUR INTERVAL = 5-FT.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

ARIZONA CANAL DIVERSION CHANNEL

SCALE: AS SHOWN

SHEET 3 OF 5

DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

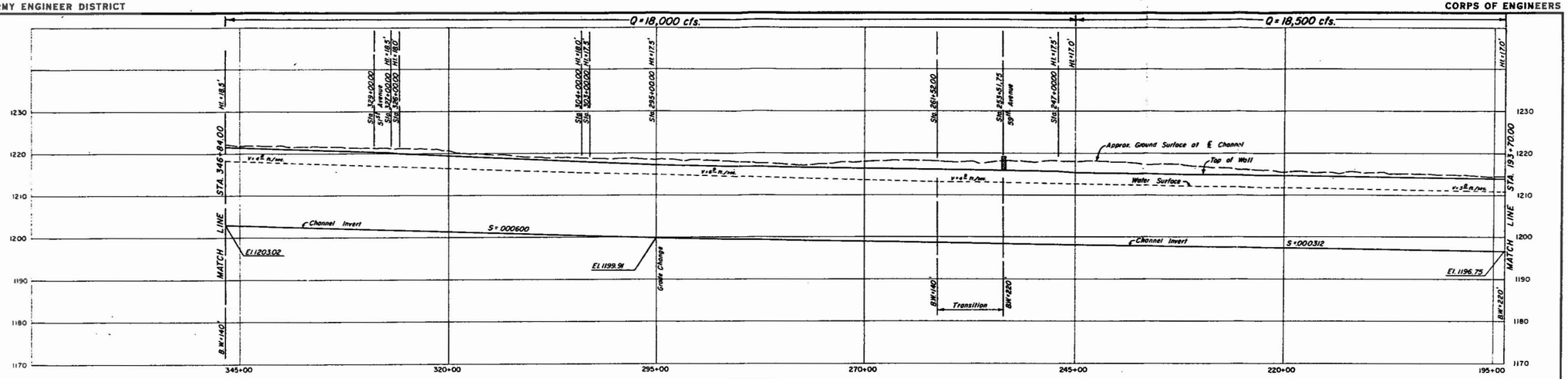
SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, ENGINEERING DIVISION	CHIEF, ENGINEERING DIVISION	COLONEL, C.E., DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (O. O. SERIES)
J.J.D. J.F.S.		C.J.B. N.E.M.	DATED: JAN 15, 1964	203/88

APPENDIX 2 PLATE 10

U.S. ARMY ENGINEER DISTRICT

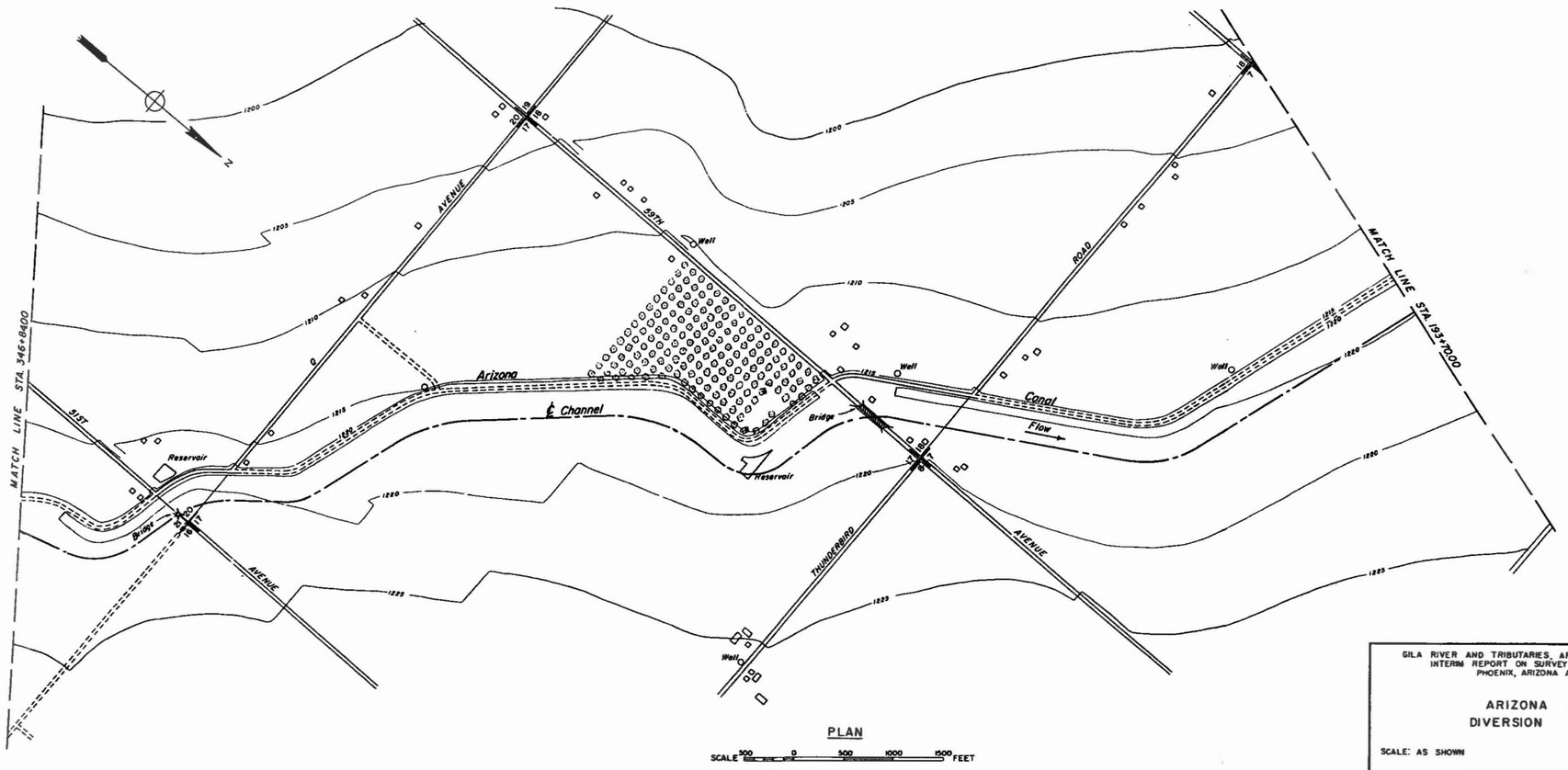
CORPS OF ENGINEERS



PROFILE

HORIZ SCALE 500 0 500 1000 1500 FEET

VERT. SCALE 10 0 10 20 30 FEET



PLAN

SCALE 500 0 500 1000 1500 FEET

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

ARIZONA CANAL
DIVERSION CHANNEL

SCALE: AS SHOWN

SHEET 4 OF 5

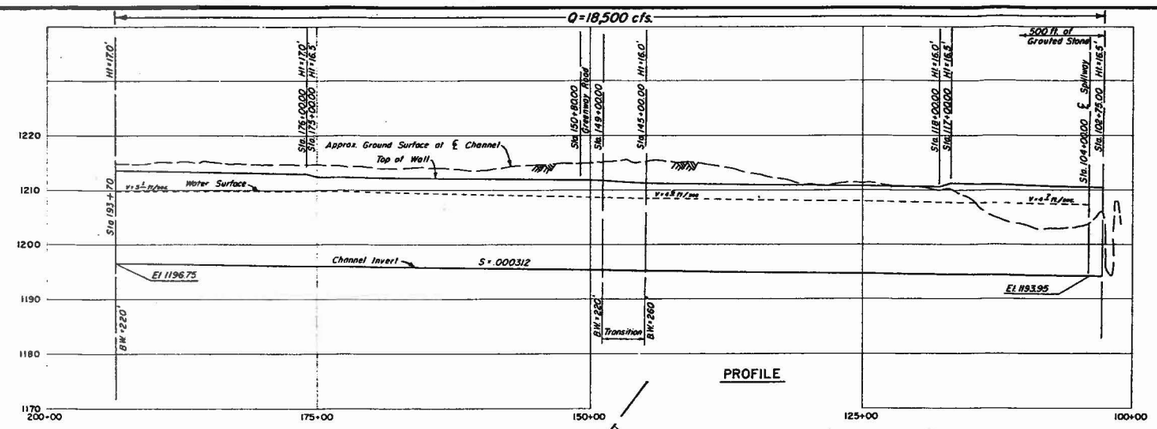
DATUM IS MEAN SEA LEVEL

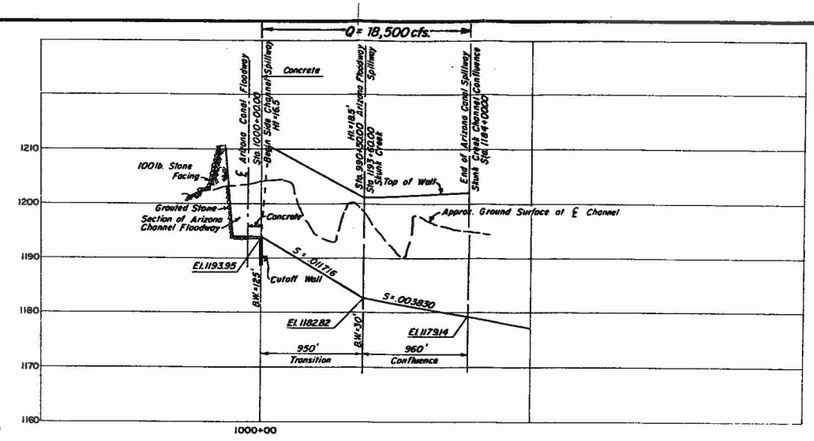
U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, DESIGN BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E. DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. 18. G. SERIES
JEP		C.J.B. C. NEM	DATED: JAN 15, 1964	209/89

APPENDIX 2 PLATE II

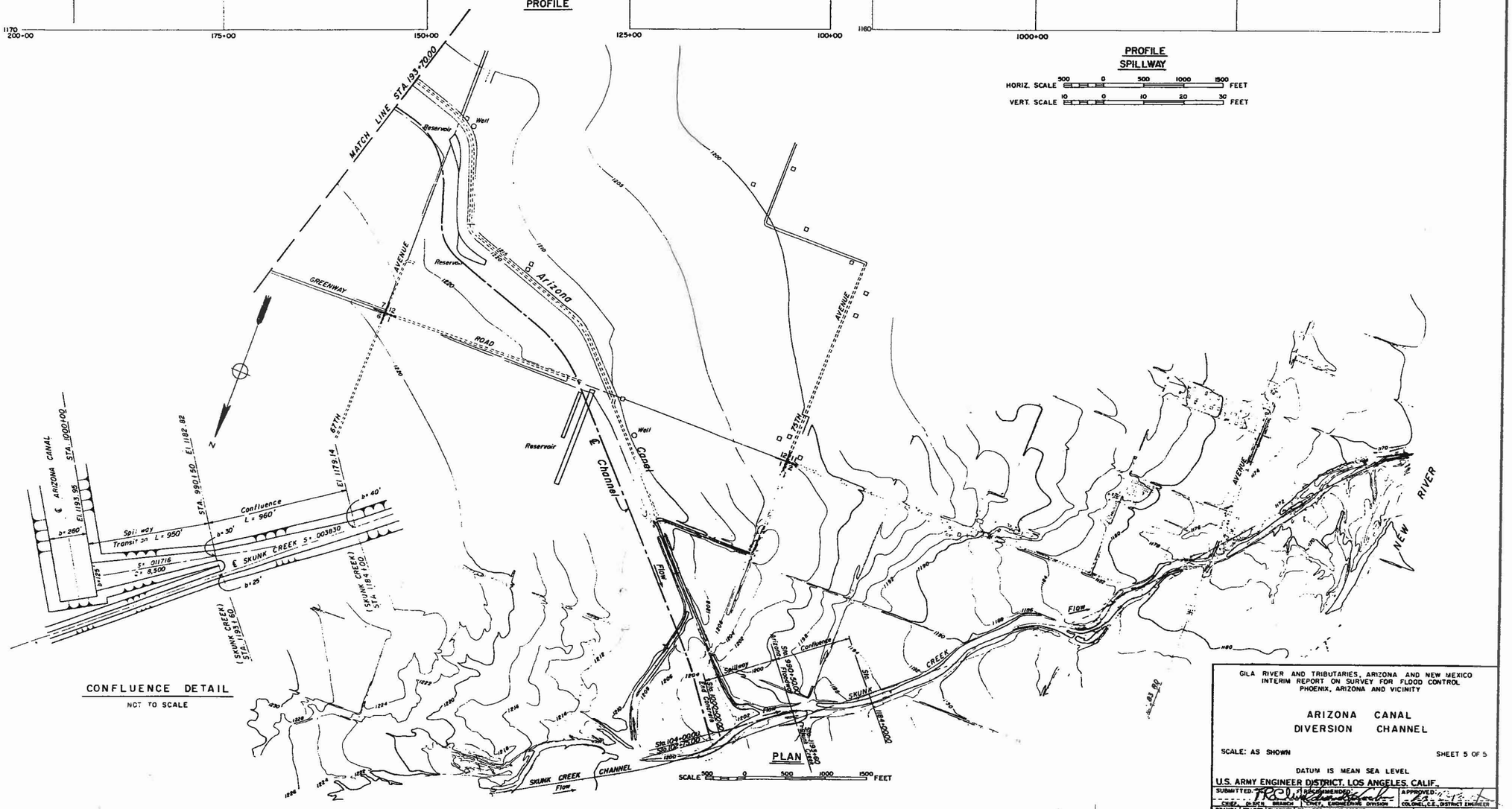




PROFILE

PROFILE
SPILLWAY

HORIZ. SCALE 500 0 500 1000 1500 FEET
VERT. SCALE 10 0 10 20 30 FEET



PLAN

CONFLUENCE DETAIL

NOT TO SCALE

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

ARIZONA CANAL
DIVERSION CHANNEL

SCALE: AS SHOWN

SHEET 5 OF 5

DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED	RECOMMENDED	APPROVED
CHIEF, PLANS BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E., DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (D. O. SERIES)
BO		C.E.B.	DATED: JAN 15, 1964	203/90

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

Q = 24,400

Q = 27,700

Q = 31,000

Transition
Skunk Creek - Union Hills Confluence

Transition

Sta 1457+71.39 Upstream end of SKUNK CREEK INVERT Sta 1454+24.62 Beginning of conc. Sta 1454+24.62

El. 1321.88

El. 1330.00

S = 0.0124

Grouted Stone

Begin Concrete

El. 1299.00

Sta 1454+24.62 SKUNK CREEK Beginning of conc. Sta 1454+24.62 Invert HL 42.0

Sta 1450+30.00 UNION HILLS Invert HL 30.0

Sta 1418+24.62

Sta 1402+18.80

Sta 1398+.05 57th Ave. Bridge

Sta 1393+40 59th AVE. - BRIDGE

Sta 1328+.70

Sta 1328+.70 HL 48.5

UNION HILLS DRIVE

HL 48.5'

MATCH LINE STA. 1285+40.00

Approx. existing ground surface

Water surface

Top of wall-Q

V= 21.0 fps

S = .005069

Invert-Q

Grade Change

El. 1241.70

Thalweg-Q

V= 28.0 fps

S = .004374

Approx. existing ground surface

El. 1222.98

b = 40'

b = 20'

b = 25'

Grade Change

Thalweg

1400
1380
1360
1340
1320
1300
1280
1260
1240
1220

1457+71.39
1450+00
1425+00
1400+00
1375+00
1350+00
1325+00
1300+00
1275+00

PROFILE

HORIZ SCALE 500 0 500 1000 1500 FEET

VERT SCALE 10 0 10 20 30 40 50 FEET

Union Hills Drive

Sta 1473+16.50 Union Hills

Sta 1454+24.62 Skunk Creek

Sta 1441+24.62

Skunk

Note:
See plate 6 for confluence structure details

PLAN

SCALE 500 0 500 1000 1500 FEET

NOTE: For typical channel section, see plate 14.

REFERENCE:
MAPS COMPILED FROM AERIAL PHOTOGRAPHS BY EARLE V. MILLER ENGINEERS, DATED DECEMBER 1962. SCALE 1:2400, CONTOUR INTERVAL= 2 FEET.

STA. 1471+00

STA. 1459+24.62

Top of levee El. 1335.00

1340

1320

Approx. ground line

1475+00

1465+00

1455+00

PROFILE OF LEFT LEVEE

PROFILE OF RIGHT LEVEE

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

SKUNK CREEK CHANNEL

SCALE: AS SHOWN

DATUM IS MEAN SEA LEVEL

SHEET 1 OF 2

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED: APPROVED:

DESIGN | TRACED | CHECKED | QUANTITIES | CHECKED | TO ACCOMPANY REPORT | FILE NO. CIV. E. 205/31

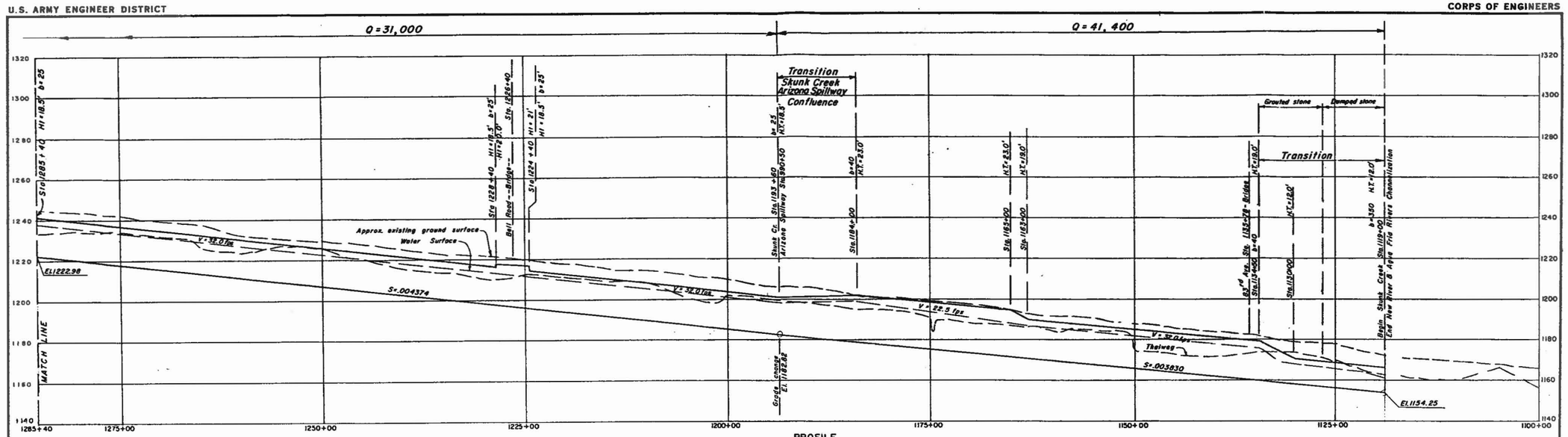
DATE: JAN. 15, 1968

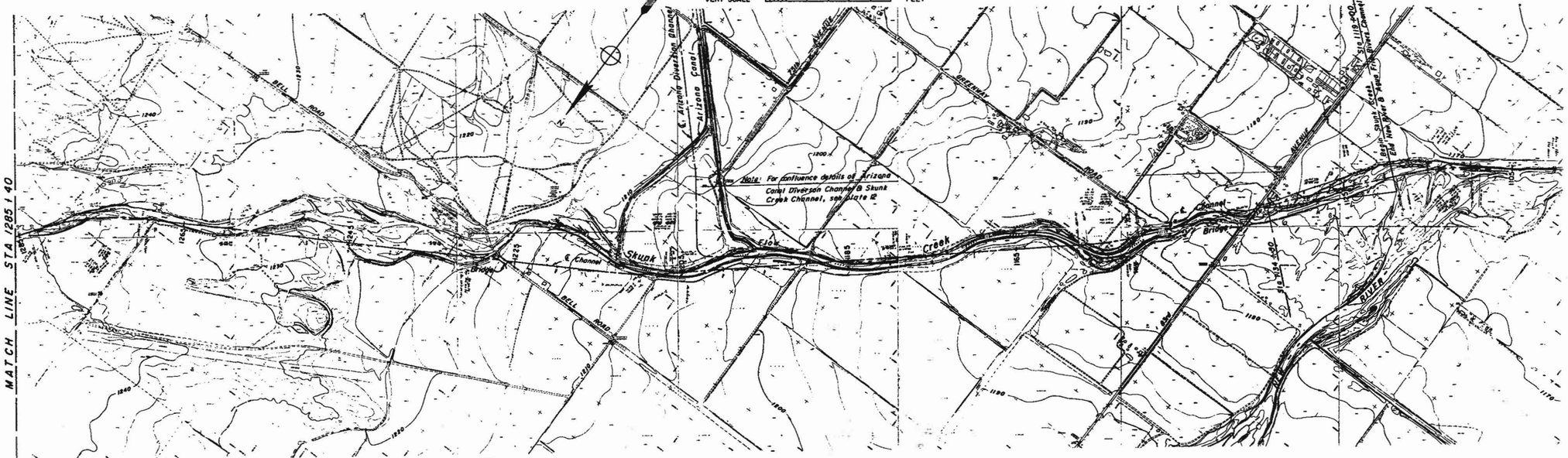
This drawing revised March 1964

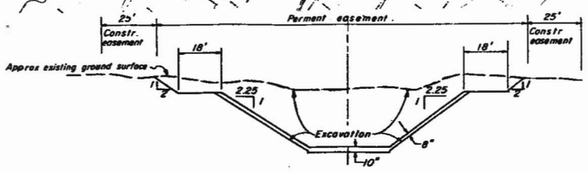
APPENDIX - 2 PLATE 13

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS







PLAN

SCALE 500 0 500 1000 1500 FEET

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

SKUNK CREEK CHANNEL

SCALE: AS SHOWN — DATUM IS MEAN SEA LEVEL — SHEET 2 OF 2

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

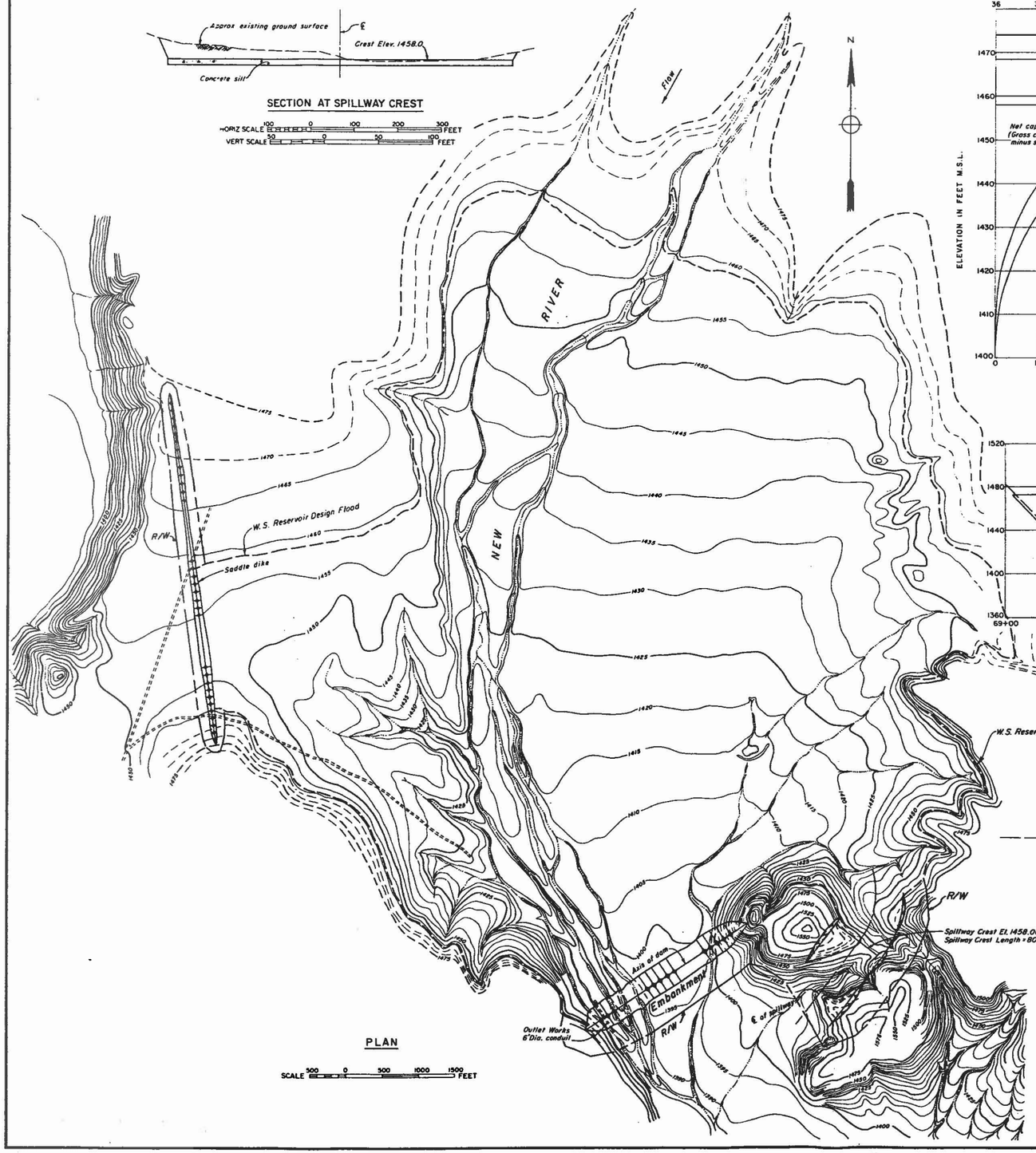
SUBMITTED: RECOMMENDED: APPROVED

CHIEF, ENGINEERING BRANCH — CHIEF, ENGINEERING DIVISION — COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (O. O. SERIES)
B.OH		C.P.B. T.W.	DATED: JAN 15, 1964	203/92

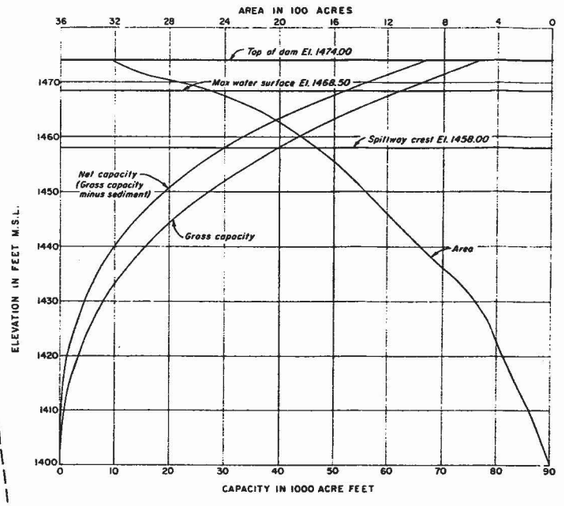
SECTION AT SPILLWAY CREST

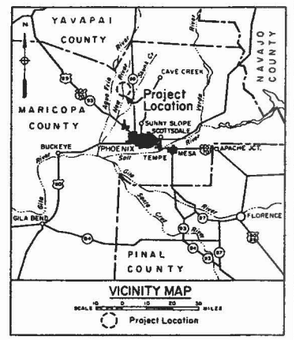
HORIZ SCALE 100 0 100 200 300 FEET
VERT SCALE 50 0 50 100 FEET

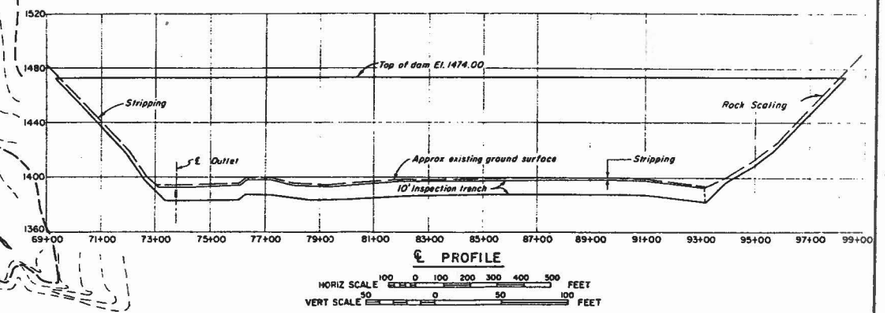


PLAN

SCALE 500 0 500 1000 1500 FEET

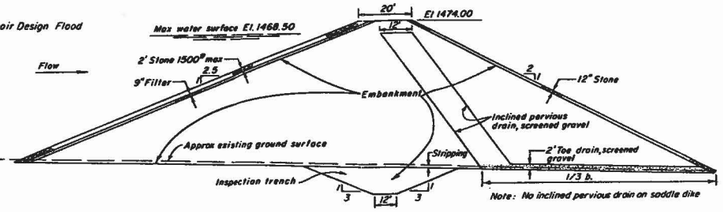






℄ PROFILE

HORIZ SCALE 100 0 100 200 300 400 500 FEET
VERT SCALE 50 0 50 100 FEET



TYPICAL SECTION

EMBANKMENT AND SADDLE DIKE

NOT TO SCALE

REFERENCE:

TOPOGRAPHY TRACED FROM USBR MAPS, COLORADO RIVER TO PHOENIX DIVERSION, PARKER-PHOENIX AQUEDUCT, SHEETS C-79, C-80 AND C-81. DASHED CONTOURS WERE INTERPOLATED FROM SPOT ELEVATIONS ON THOSE SHEETS.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

NEW RIVER DETENSION BASIN

SCALE: AS SHOWN — SHEET 1 OF 1

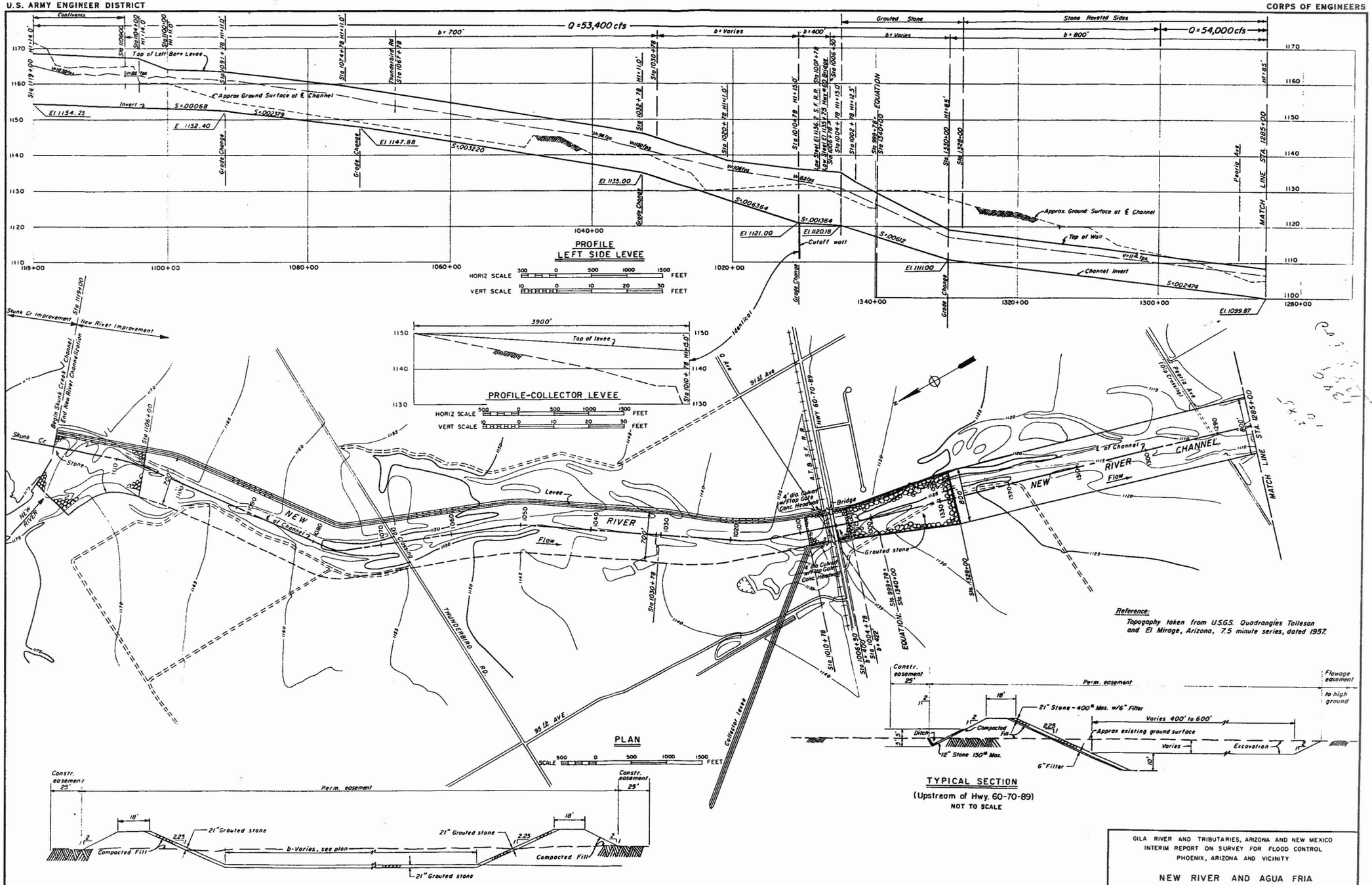
DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, DESIGN BRANCH	CHIEF ENGINEERING DIVISION	COLONEL, C.E. DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. I.B. O. SERIES
J.E.P.	C.I.B.	K.E.M.	DATED: JAN 15, 1964	203/93

U.S. ARMY ENGINEER DISTRICT — CORPS OF ENGINEERS



Reference:
Topography taken from U.S.G.S. Quadrangles Tolleson and El Mirage, Arizona, 7.5 minute series, dated 1957.

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

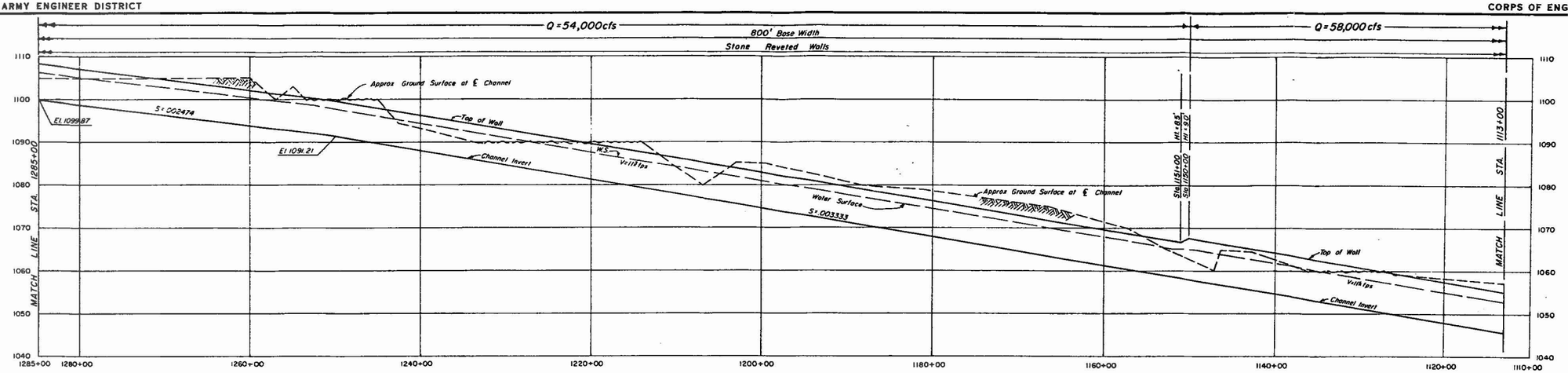
NEW RIVER AND AGUA FRIA RIVER CHANNELIZATION

SCALE: AS SHOWN — SHEET 1 OF 5
DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED: CHIEF, DESIGN BRANCH	RECOMMENDED: CHIEF, ENGINEERING DIVISION	APPROVED: COLONEL, CE, DISTRICT ENGINEER
DRAWN: B.O'H. / TRACED	CHECKED: C.J.B. N.E.M.	TO ACCOMPANY REPORT DATED: JAN 15, 1964
		FILE NO. I.D.O. SERIES 203/94

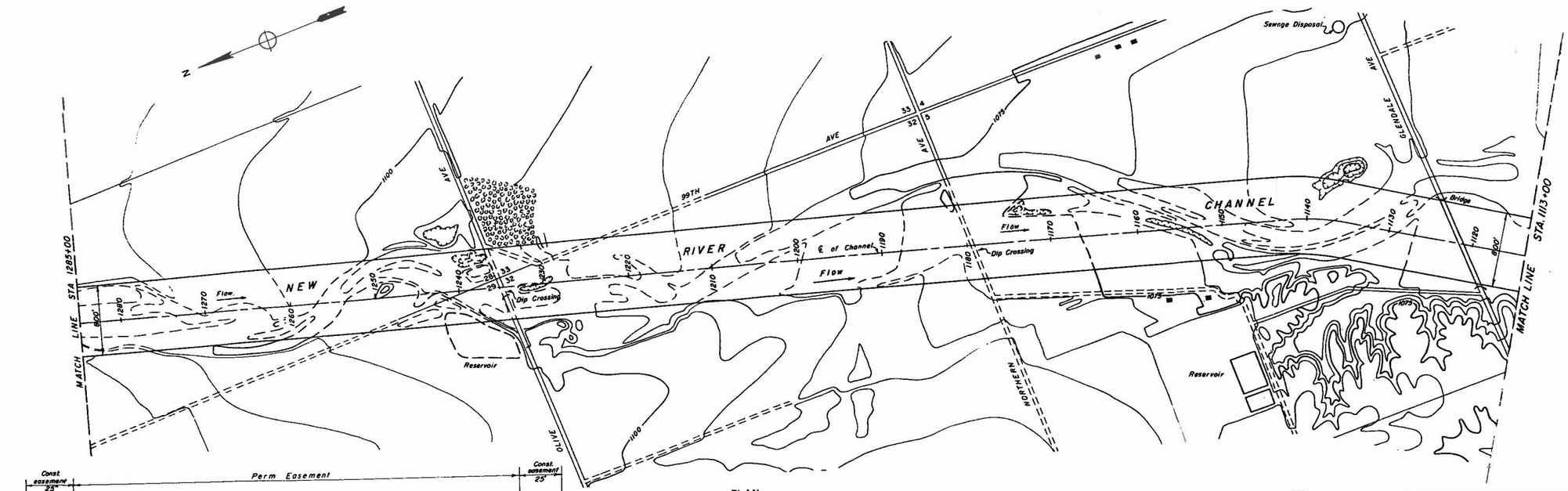
U.S. ARMY ENGINEER DISTRICT — CORPS OF ENGINEERS



PROFILE

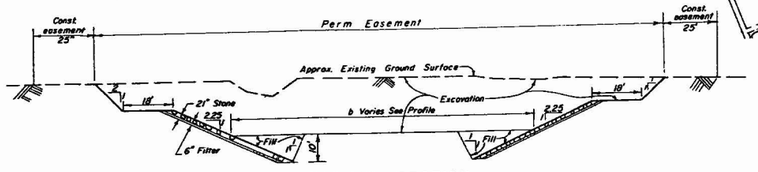
HORIZ. SCALE 500 0 500 1000 1500 FEET

VERT. SCALE 10 0 10 20 30 FEET



PLAN

SCALE 500 0 500 1000 1500 FEET



TYPICAL SECTION

STA 1328+00 TO McDOWELL ROAD

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

NEW RIVER AND AGUA FRIA RIVER CHANNELIZATION

SCALE AS SHOWN — SHEET 2 OF 5

DATUM IS MEAN SEA LEVEL

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

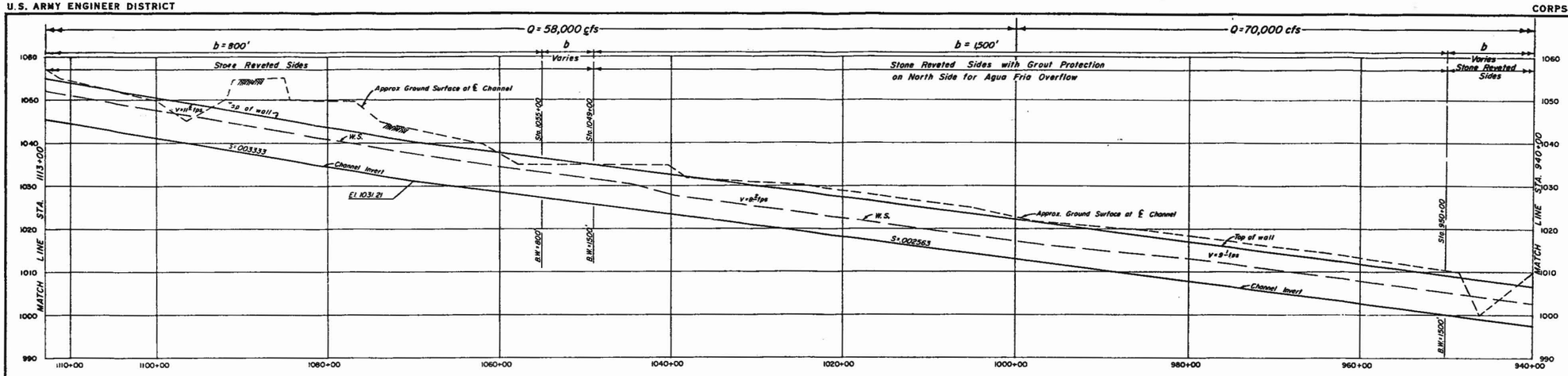
SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, [illegible] BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, CE DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. ID. O. 5283253
L.L.M.		C.A.B. N.E.M.	DATED: JAN 15, 1964	203/95

APPENDIX 2 PLATE 17

U.S. ARMY ENGINEER DISTRICT

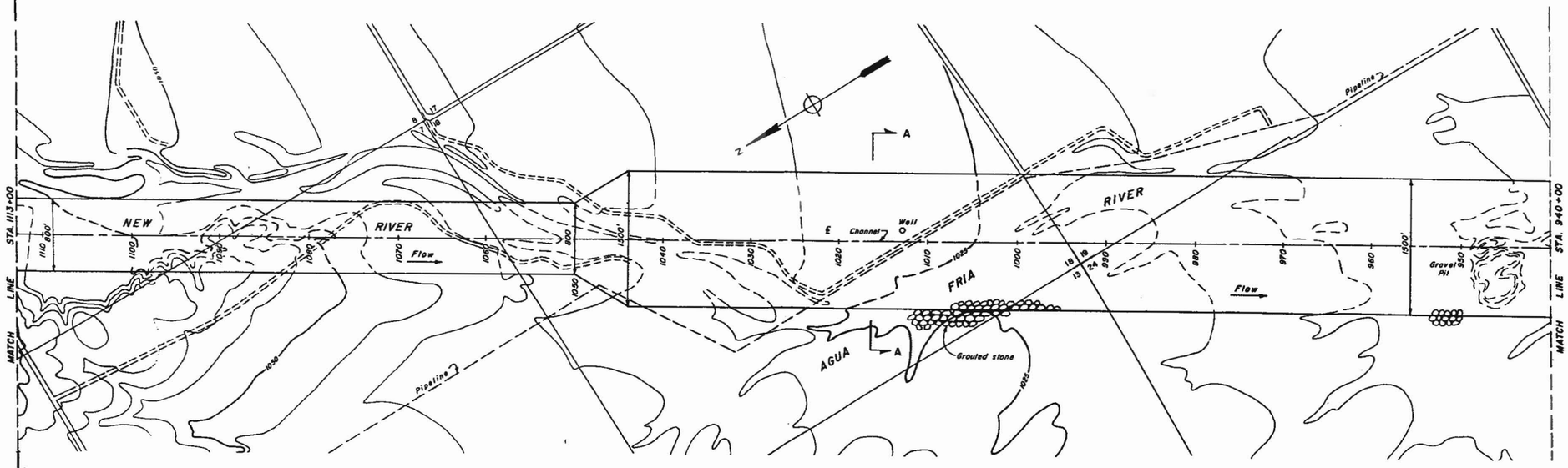
CORPS OF ENGINEERS

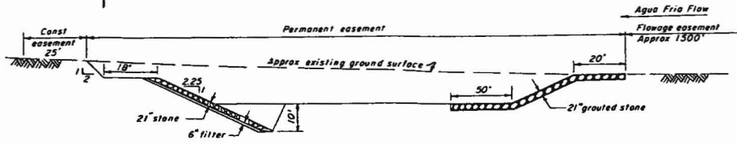


PROFILE

HORIZ. SCALE 500 0 500 1000 1500 FEET

VERT SCALE 10 0 10 20 30 FEET





SECTION A-A

AGUA FRIA INLET

NOT TO SCALE

PLAN

HORIZ. SCALE 500 0 500 1000 1500 FEET

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

NEW RIVER AND AGUA FRIA RIVER CHANNELIZATION

SCALE: AS SHOWN

SHEET 3 OF 5

DATUM IS MEAN SEA LEVEL

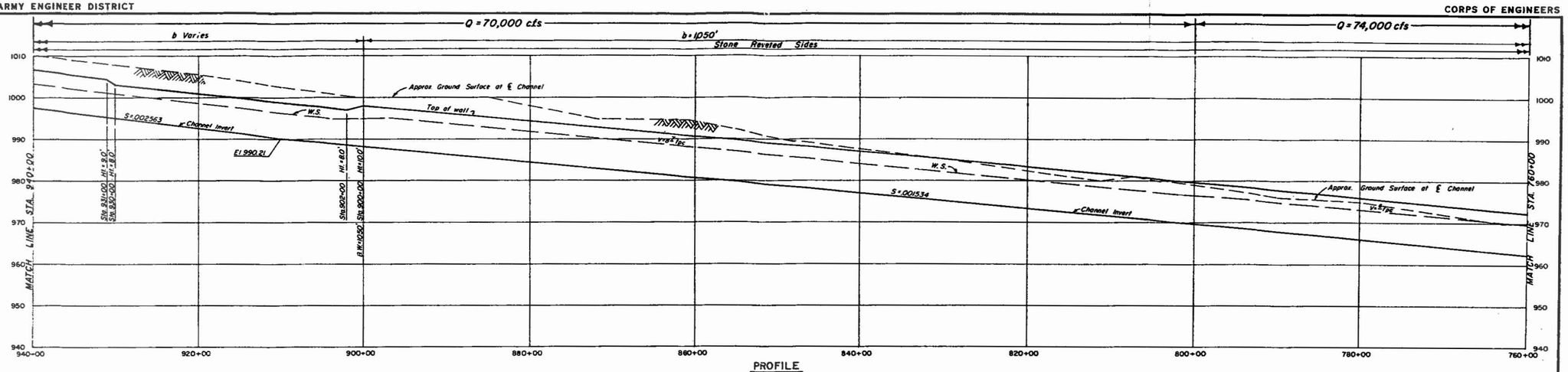
U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, DESIGN BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E. DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (D. O. SERIES)
L.L.M.		C.J.B. H.E.S.	DATED: JAN 15, 1964	203/96

U.S. ARMY ENGINEER DISTRICT

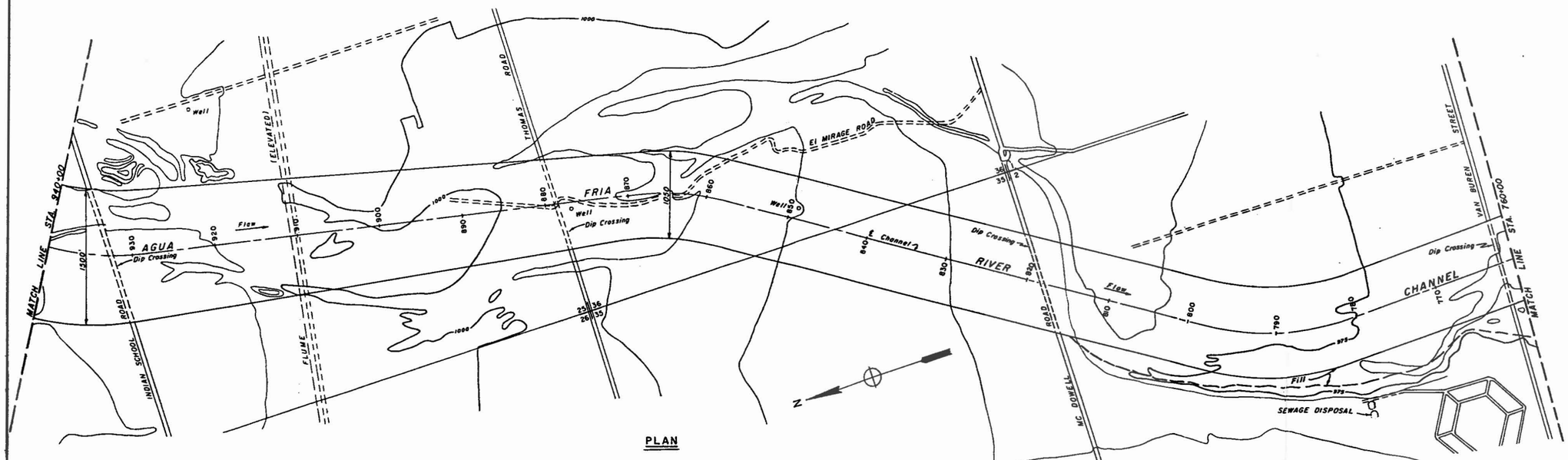
CORPS OF ENGINEERS



PROFILE

HORIZ SCALE: 500 0 500 1000 1500 FEET

VERT SCALE: 10 0 10 20 30 FEET



PLAN

SCALE: 500 0 500 1000 1500 FEET

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

NEW RIVER AND AGUA FRIA
RIVER CHANNELIZATION

SCALE AS SHOWN — DATUM IS MEAN SEA LEVEL — SHEET 4 OF 5

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED:	RECOMMENDED:	APPROVED:
CHIEF, DESIGN BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E. DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (U. S. SERIES)
L.L.M.		C.J.B. R.E.M.	DATED: JAN 15, 1964	203/97

APPENDIX 2 PLATE 19

Phase B Rept
Plate 20, App 2

November 25, 1970

MEMO FOR FILE

SUBJECT: Agua Fria River Channel, Phase B Report

I received a call from Pace Associates (R. Gutierrez) regarding a tract in Section 14, T1N, R1W, on the east side of the Agua Fria River. They noted that plate 20, Appendix 2, of the report indicated a "flowage easement" in this area and asked what it meant and what was required.

I called F. Carroll at the District Office, Los Angeles, and received the following information on November 24.

a. Flowage easement was considered best solution at the time the project was developed. Only a narrow zone was affected, and construction of a dike did not seem economically justified at that time.

b. There is no objection to the property owner filling this area. The Flood Control District could fill it if desired, and it is possible that enough spoil might be available during construction to provide the required fill (note that fill <u>will</u> be required on the west bank also).

c. At the time the channel is being designed, consideration can be then given to construction of a dike on the east side if it is desirable.

I advised Pace Associates of this. I stated also that we would state that any development referred to us would carry our added remarks:

a. The area is now subject to flooding.

b. Inasmuch as it is now subject to flooding, we see no need to acquire the land by easement. It would remain unprotected if a dike were not found justified.

c. There would be no objection to filling or developing the area, if the threat of inundation were recognized.

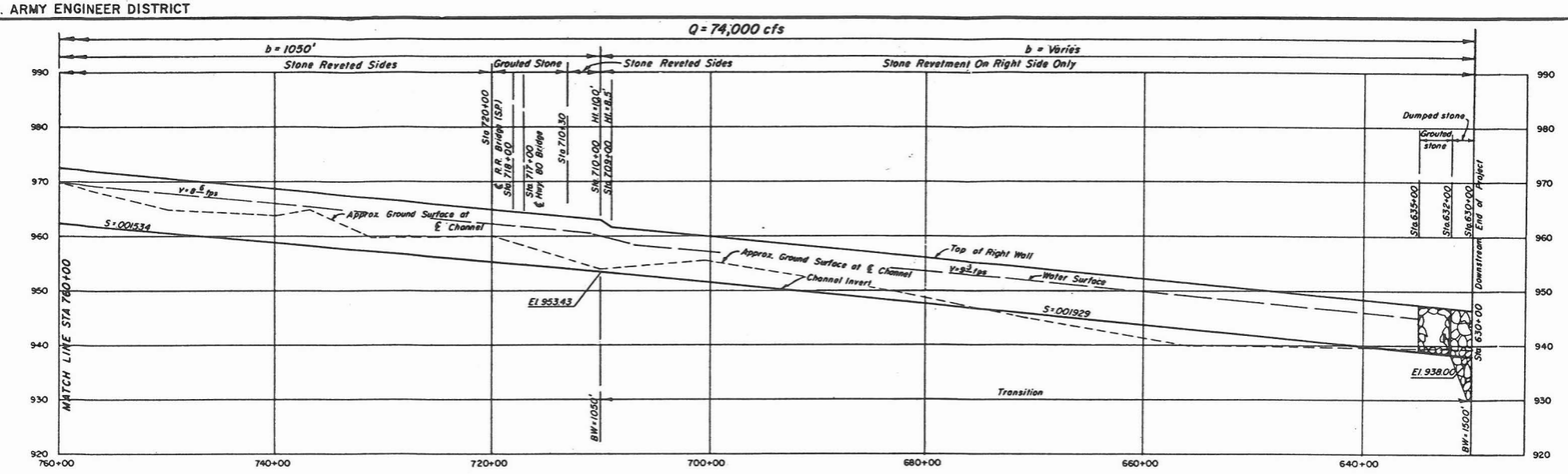
L. E. Ohsiek

L. E. Ohsiek

LEO/dr

U.S. ARMY ENGINEER DISTRICT

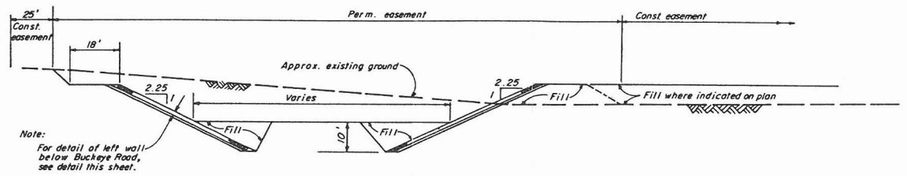
CORPS OF ENGINEERS



PROFILE

HORIZ. SCALE: 500 0 500 1000 1500 FEET

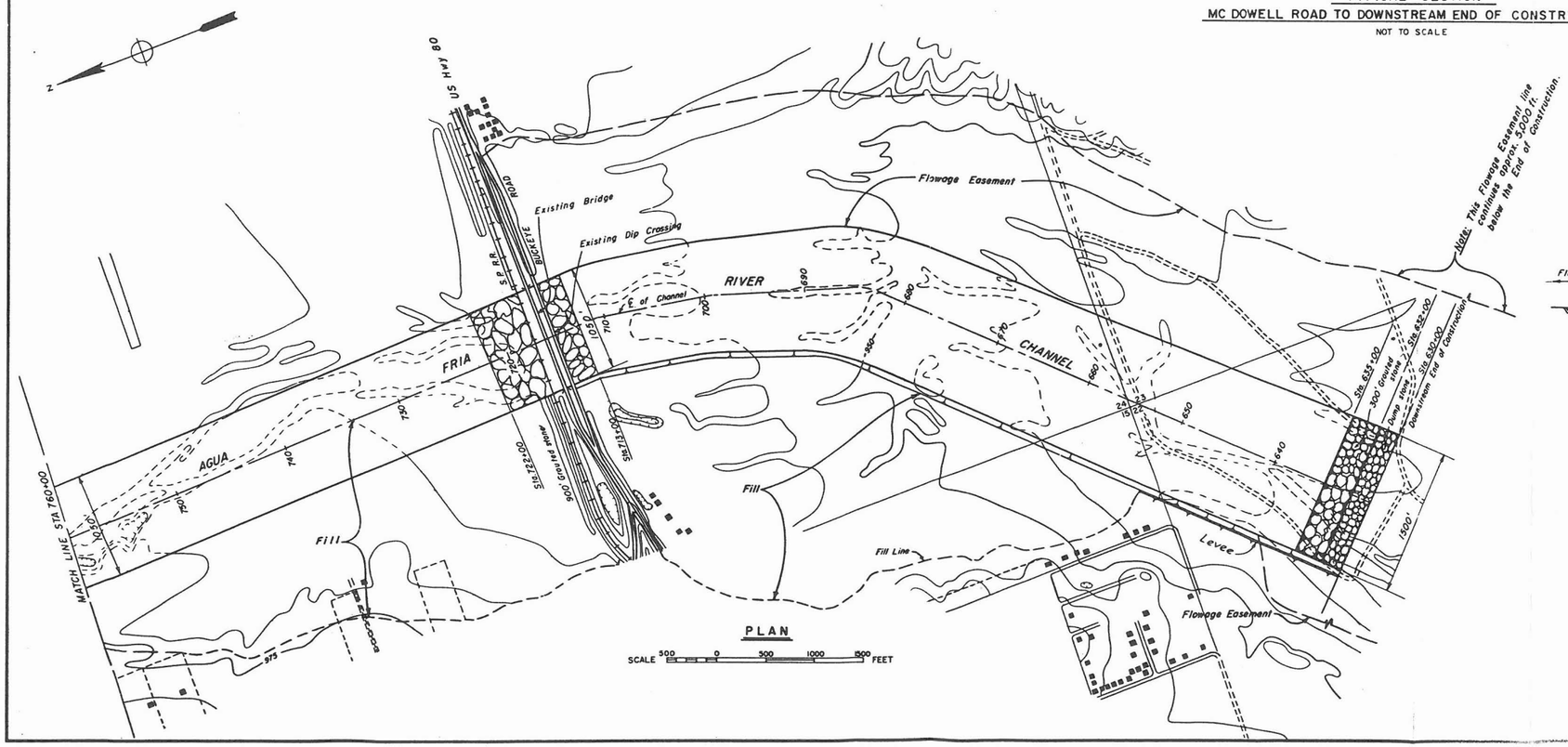
VERT. SCALE: 10 0 10 20 30 FEET



TYPICAL SECTION

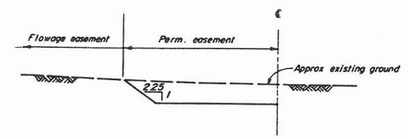
MC DOWELL ROAD TO DOWNSTREAM END OF CONSTRUCTION

NOT TO SCALE



PLAN

SCALE 500 0 500 1000 1500 FEET



LEFT WALL DETAIL BELOW BUCKEYE ROAD

NOT TO SCALE

GILA RIVER AND TRIBUTARIES, ARIZONA AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY

NEW RIVER AND AGUA FRIA RIVER CHANNELIZATION

SCALE: AS SHOWN

SHEET 5 OF 5

DATUM IS MEAN SEA LEVEL

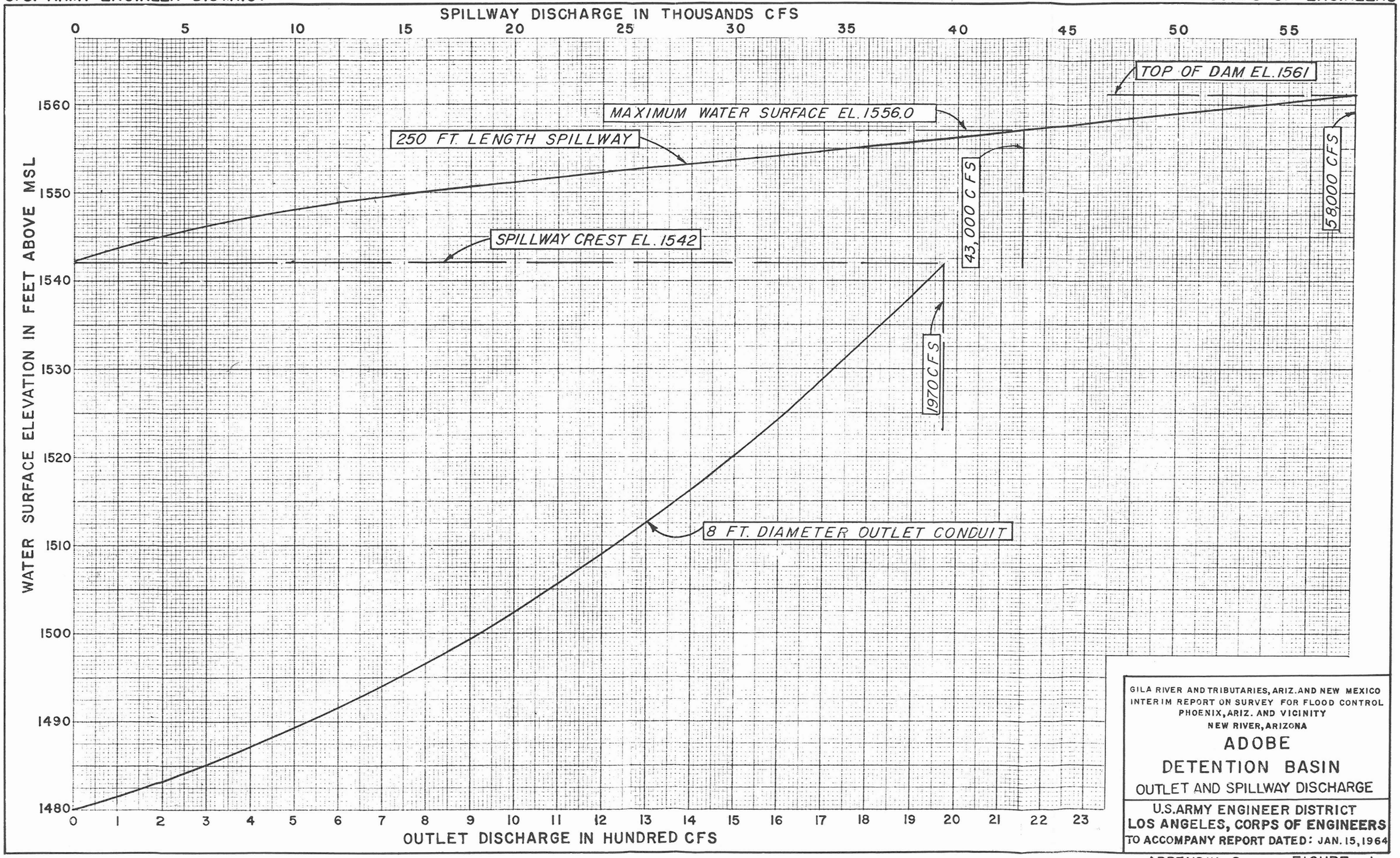
U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF.

SUBMITTED	RECOMMENDED	APPROVED
CHIEF, DESIGN BRANCH	CHIEF, ENGINEERING DIVISION	COLONEL, C.E., DISTRICT ENGINEER

DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT	FILE NO. (D. O. SERIES)
L.L.M.		C.J.B. N.F.M.	DATED: JAN 15, 1964	203/98

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



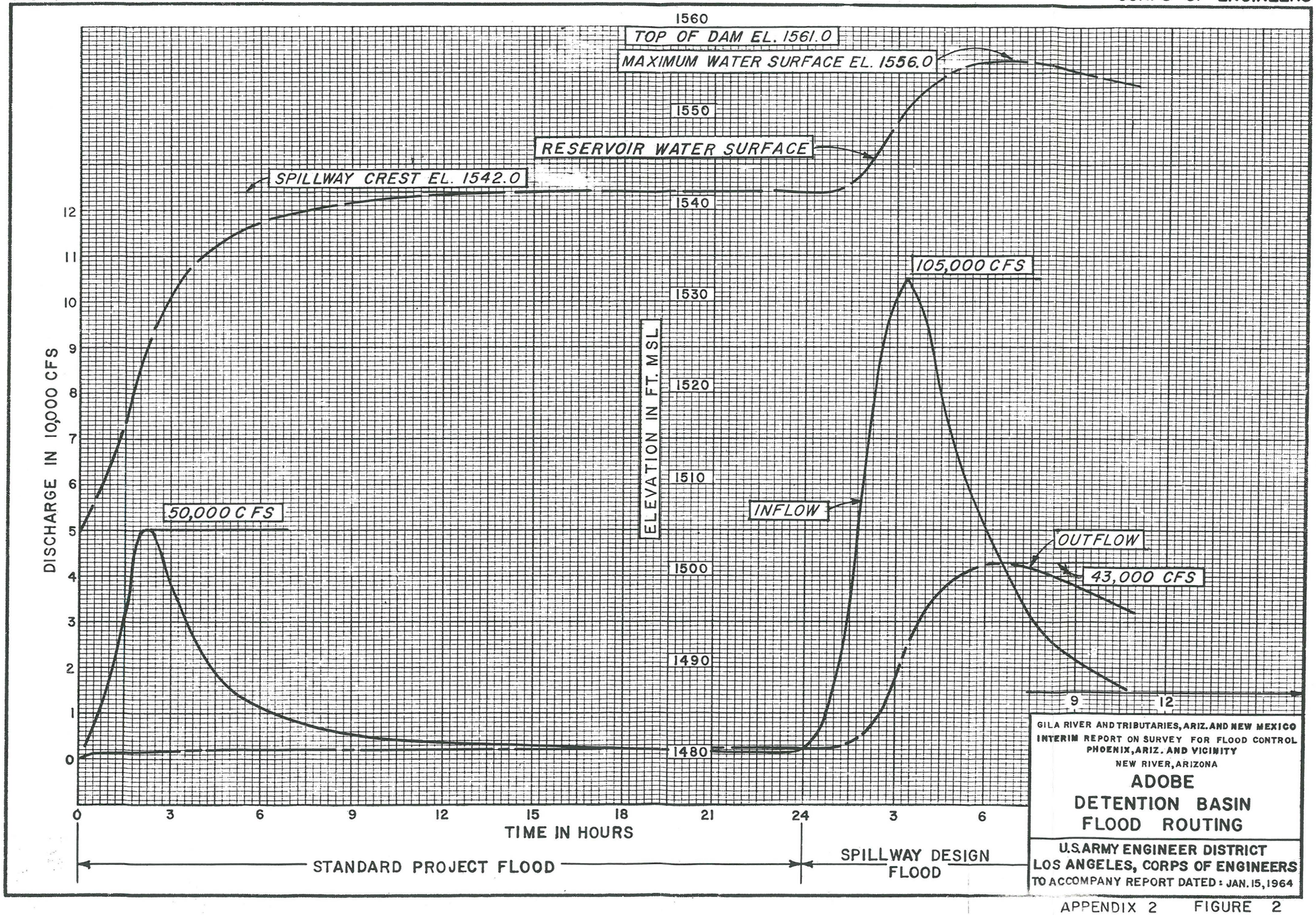
GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. AND VICINITY
NEW RIVER, ARIZONA

ADOBE DETENTION BASIN

OUTLET AND SPILLWAY DISCHARGE

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

APPENDIX 2 FIGURE 1

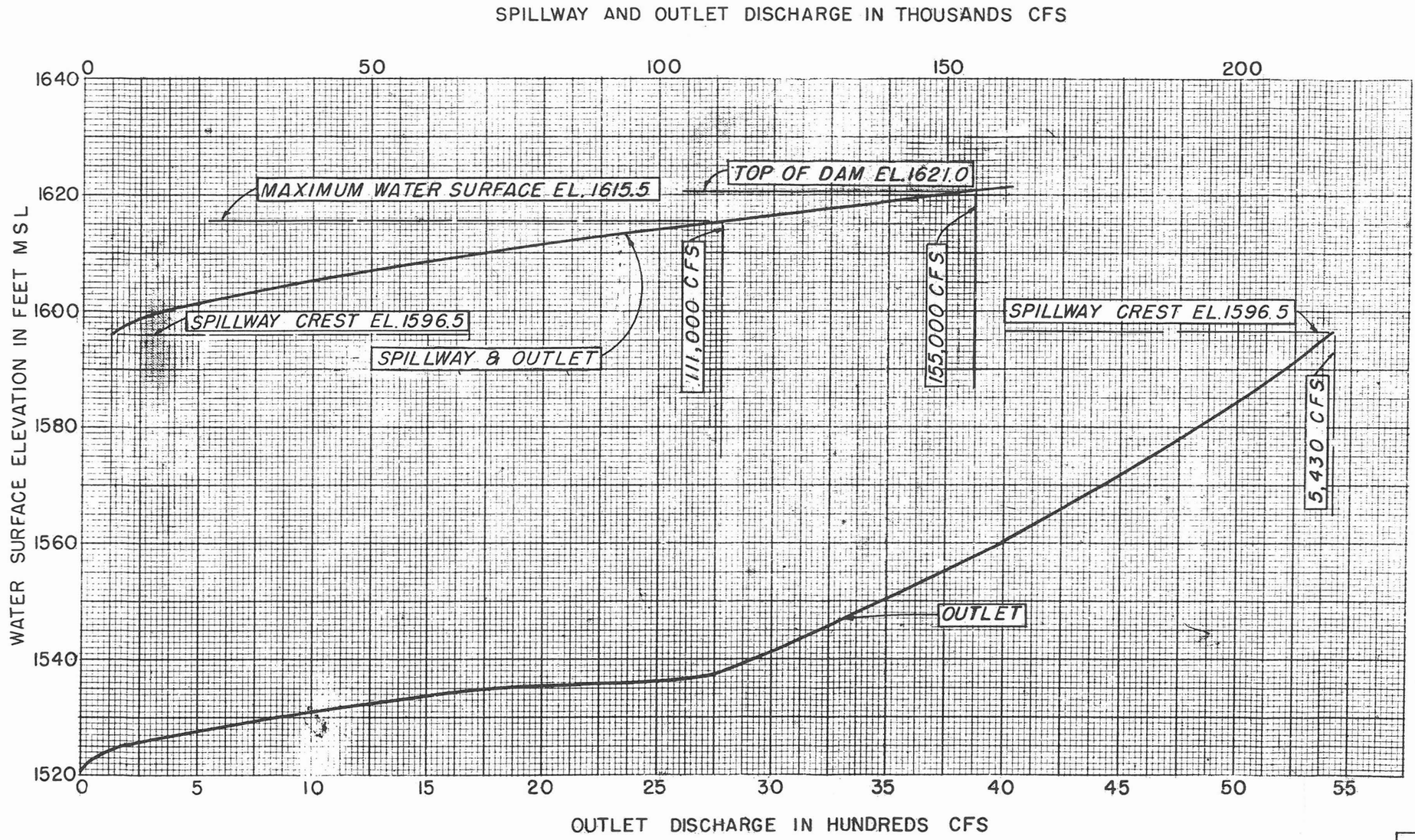


GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. AND VICINITY
NEW RIVER, ARIZONA

ADOBE DETENTION BASIN FLOOD ROUTING

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

APPENDIX 2 FIGURE 2



GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. AND VICINITY
NEW RIVER, ARIZONA

CAVE BUTTES DETENTION BASIN

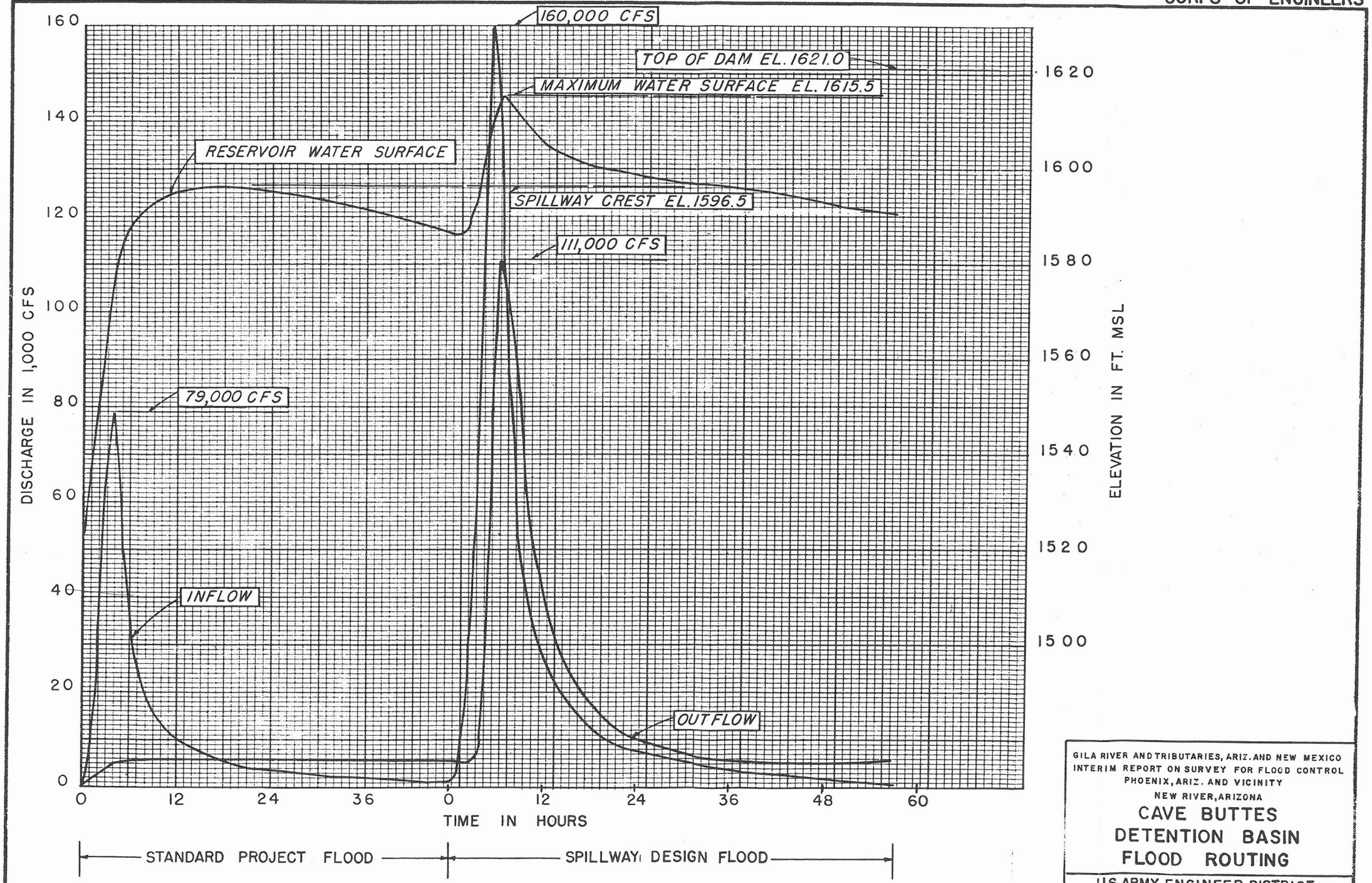
OUTLET AND SPILLWAY DISCHARGE

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

APPENDIX 2 FIGURE 3

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. AND VICINITY
NEW RIVER, ARIZONA

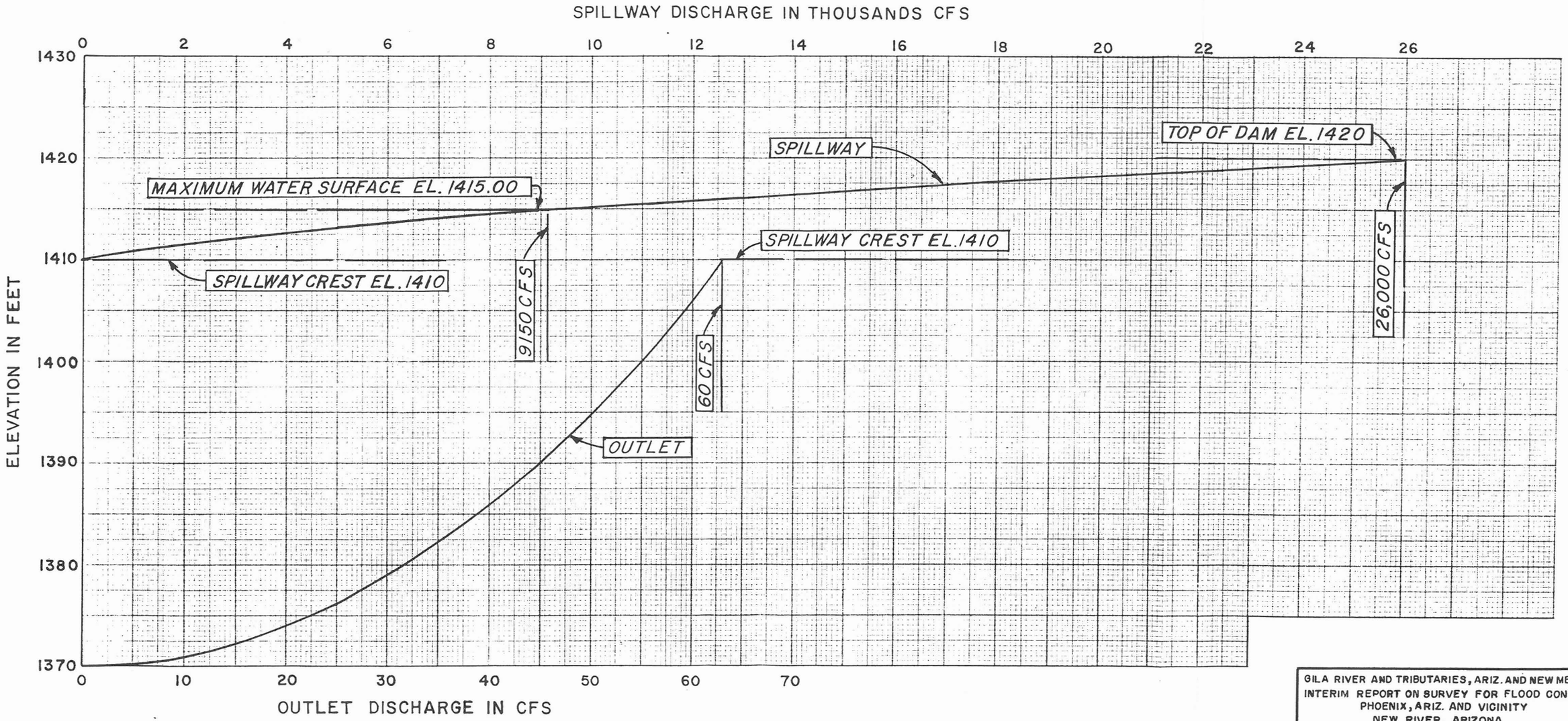
CAVE BUTTES DETENTION BASIN FLOOD ROUTING

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

APPENDIX 2 FIGURE 4

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. AND VICINITY
NEW RIVER, ARIZONA

DREAMY DRAW DETENTION BASIN

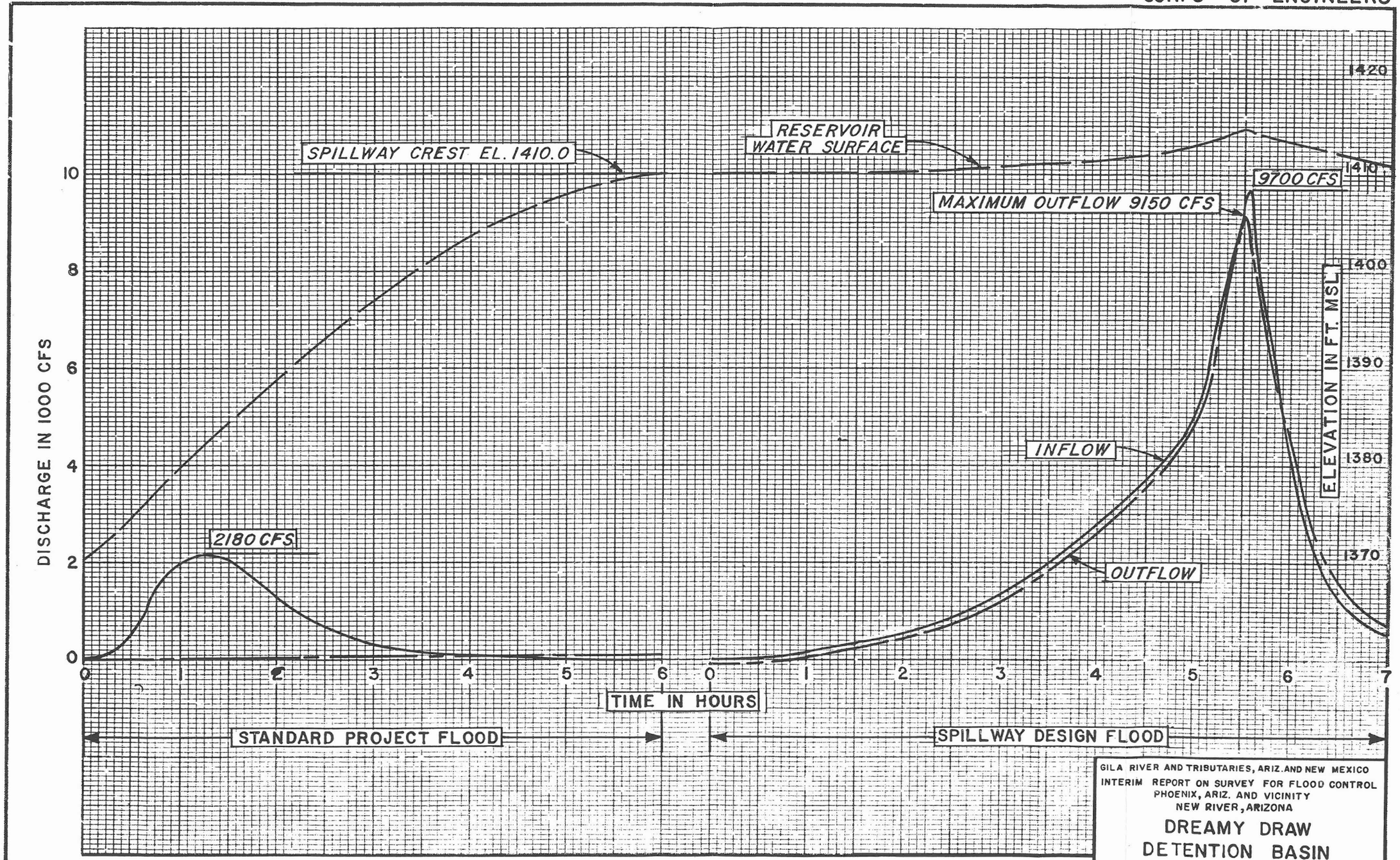
OUTLET AND SPILLWAY DISCHARGE

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

APPENDIX 2 FIGURE 5

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

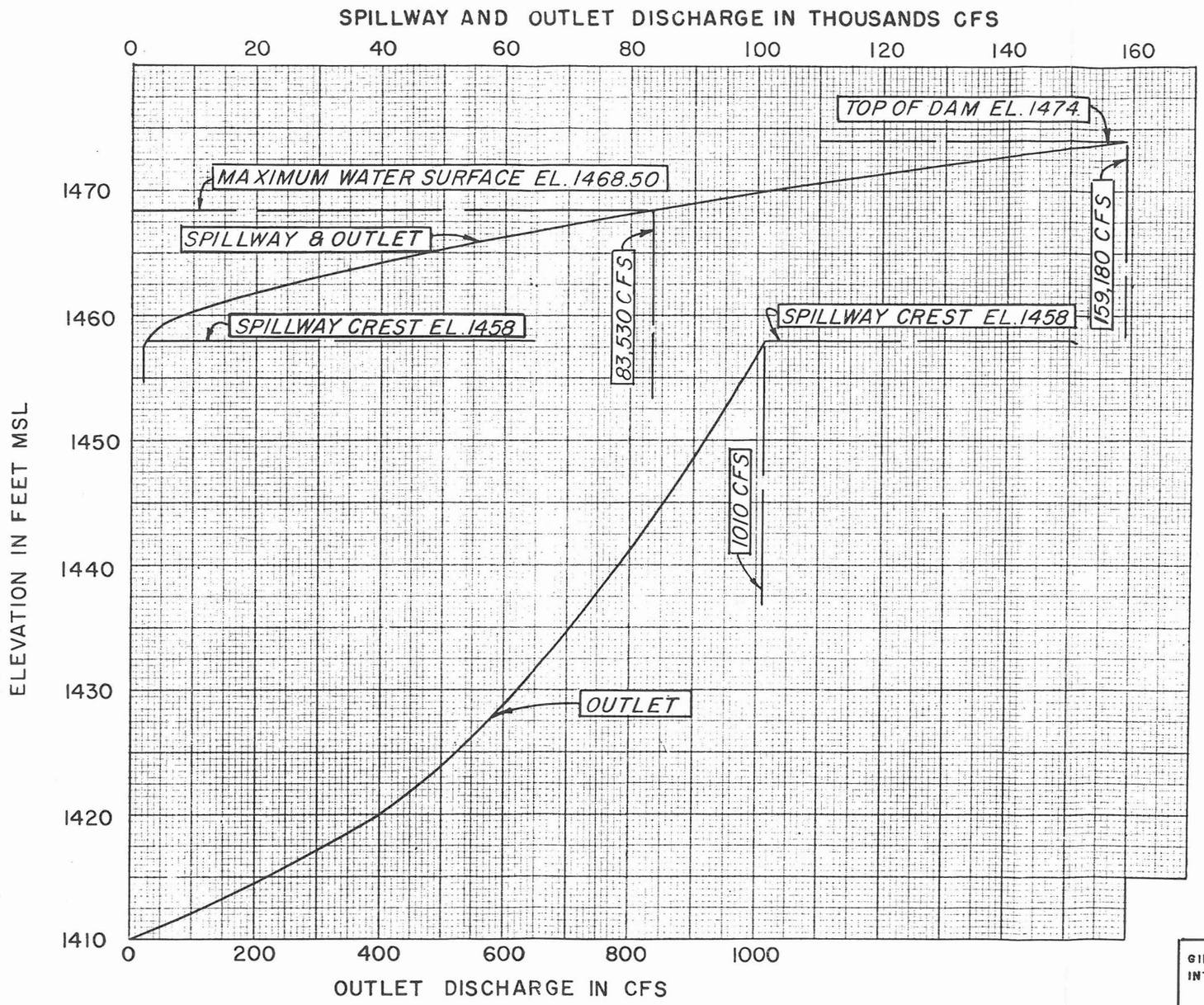


GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. AND VICINITY
NEW RIVER, ARIZONA

DREAMY DRAW DETENTION BASIN FLOOD ROUTING

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

APPENDIX 2 FIGURE 6



GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. AND VICINITY
NEW RIVER, ARIZONA

NEW RIVER DETENTION BASIN

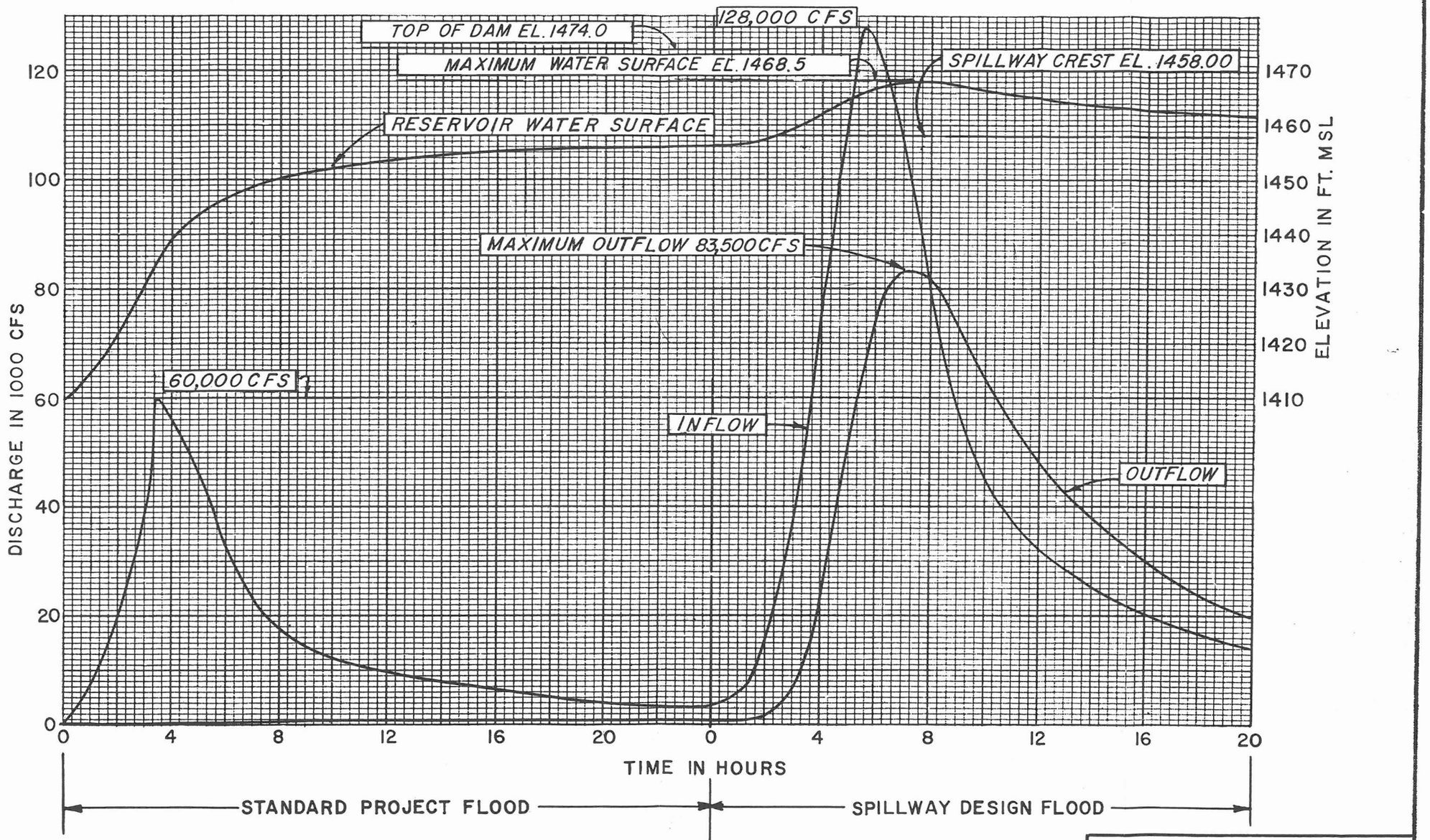
OUTLET AND SPILLWAY DISCHARGE

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

APPENDIX 2 FIGURE 7

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEXICO
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. AND VICINITY
NEW RIVER, ARIZONA

NEW RIVER DETENTION BASIN FLOOD ROUTING

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

APPENDIX 2 FIGURE 8

APPENDIX 3 - COST ESTIMATES

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

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Maintenance and operation	3-1
Rights-of-way	3-1
Estimated cost summary	3-2

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Cost estimate for New River and Agua Fria River channelization	3-21

COST ESTIMATES

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

1. General.--This appendix presents the detailed estimate of construction and maintenance costs of the recommended improvements for flood control in that part of the Phoenix metropolitan area that is considered in detail in the main report.

2. The estimated first costs include estimates for construction, relocations, rights-of-way, engineering and design, and supervision and administration. Construction costs include allowances for contingencies. Costs of preauthorization studies are not included in the estimates.

3. Unit prices.--Unit prices were developed by using current material, equipment, and labor costs typical of work of this nature in the vicinity of the site of the recommended improvements. All unit prices are based on prices prevailing in October 1963.

4. Construction period.--The construction period for each of the recommended improvements is shown in the following table:

Unit	Years for construction
Adobe detention basin and diversion channel	2
Cave Buttes detention basin	2
Cave Creek channel	1
Union Hills diversion channel	2
Dreamy Draw detention basin	1
Arizona Canal diversion channel and Dreamy Draw channel	4
Skunk Creek channel	2
New River detention	1
New River and Agua Fria River channelization	4

5. Maintenance and operation.--Average annual maintenance charges for the recommended improvements are estimated at $228,000. Maintenance would include periodic inspection of the work, removal of debris, and repair of damage to the structures.

6. Rights-of-way.--The site of the proposed improvements was inspected in December 1962. The real-estate market concerned was analyzed to make an appraisal of cost. The estimates for rights-of-way reflect cost of acquisition.

7. Estimated cost summary.--A summary of the estimated costs for the units of the recommended plan is given in the following table:

Estimated first costs of improvements under the recommended plan, Phoenix, Ariz., and vicinity (including New River) based on October 1963 prices

Unit of improvement	Federal first cost	Non-Federal first cost	Total first cost
Adobe detention basin and channel	$3,800,000	$850,000	$4,650,000
Cave Buttes detention basin	6,490,000	260,000	6,750,000
Cave Creek channel	1,840,000	60,000	1,900,000
Union Hills diversion channel	7,200,000	1,300,000	8,500,000
Dreamy Draw detention basin	330,000	130,000	460,000
Dreamy Draw channel	820,000	80,000	900,000
Arizona Canal diversion channel	11,400,000	4,200,000	15,600,000
Skunk Creek channel	7,100,000	360,000	7,460,000
New River detention basin	2,900,000	480,000	3,380,000
New and Agua Fria Rivers channel improvements	17,800,000	3,400,000	21,200,000
Total	59,680,000	11,120,000	70,800,000

Cost estimate for recommended Adobe detention basin and diversion channel, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
04.	Dam:					
.1	Main embankment:					
	Clearing	Job		Lump sum	$5,000	
	Stripping	Cu. yd.	40,000	$0.40	16,000	
	Scaling, abutments	Cu. yd.	20,000	4.00	80,000	
	Excavation, trench	Cu. yd.	60,000	.40	24,000	
	Embankment	Cu. yd.	1,230,000	.60	738,000	
	Stone revetment	Cu. yd.	50,000	5.00	250,000	
	Filter	Cu. yd.	140,000	1.50	210,000	
	Contingencies				207,000	
	Subtotal, main embankment				1,530,000	
.2	Outlet works	Job		Lump sum	170,000	
.5	Auxiliary dam (spillway):					
	Excavation	Cu. yd.	3,000	2.00	6,000	
	Concrete sill	Job		Lump sum	19,000	
	Contingencies				5,000	
	Subtotal, spillway				30,000	
	Total, dam					$1,730,000
09.	Channel improvement:					
	Clearing and grubbing	Job		Lump sum	5,000	
	Excavation, channel	Cu. yd.	2,000,000	.45	900,000	
	Excavation, toe	Cu. yd.	90,000	.35	31,500	

Cost estimate for recommended Adobe detention basin and diversion channel, Phoenix, Ariz., and vicinity (including New River)--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
09.	Channel improvement--Continued:					
	Backfill, toe	Cu. yd.	70,000	$0.15	$10,500	
	Stripping	Cu. yd.	40,000	.40	16,000	
	Embankment	Cu. yd.	310,000	.20	62,000	
	Stone revetment	Cu. yd.	56,000	5.00	280,000	
	Filter	Cu. yd.	15,000	1.50	22,500	
	Contingencies				192,500	
	Total, channel improvement					$1,520,000
30.	Engineering and design					370,000
31.	Supervision and administration					180,000
	Total, project first cost to the United States					3,800,000
	NON-FEDERAL COSTS					
	Rights-of-way				350,000	
	Relocations:					
	Utilities				10,000	
	Highways and bridges				490,000	
	Total, project first cost to local interests					850,000
	Total, project first cost					4,650,000

Cost estimate for the recommended Cave Buttes detention basin, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
04.	Dam:					
.1	Main embankment:					
	Clearing and grubbing	Job		Lump sum	$5,000	
	Diversion and control of water.	do		do	15,000	
	Embankment fill	Cu. yd.	1,715,000	$0.60	1,029,000	
	Scaling rock abutment	Cu. yd.	17,600	7.50	132,000	
	Excavation, trench	Cu. yd.	32,000	.40	12,800	
	Excavation, stripping	Cu. yd.	33,000	.40	13,200	
	Stone revetment	Cu. yd.	48,800	5.00	244,000	
	Gravel filter and toe drain	Cu. yd.	111,400	1.50	167,100	
	Access road	Job		Lump sum	25,000	
	Contingencies				246,900	
	Subtotal, main embankment				1,890,000	
.2	Outlet works	Job		Lump sum	280,000	

Cost estimate for the recommended Cave Buttes detention basin, Phoenix, Ariz., and vicinity (including New River)--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
04.	Dam--Continued:					
.5	Auxiliary dam (west dike):					
	Clearing and grubbing	Job		Lump sum	$5,000	
	Embankment fill	Cu. yd.	1,880,000	$0.60	1,128,000	
	Scaling rock abutment	Cu. yd.	9,800	7.50	73,500	
	Excavation (stripping and toe).	Cu. yd.	44,500	.40	17,800	
	Stone revetment	Cu. yd.	57,200	5.00	286,000	
	Gravel filter and toe drain	Cu. yd.	14,000	1.50	21,000	
	Contingencies				228,700	
	Subtotal, west dike				1,760,000	
	Auxiliary dam (east dike):					
	Clearing and grubbing	Job		Lump sum	5,000	
	Embankment fill	Cu. yd.	1,155,000	.60	693,000	
	Scaling rock abutment	Cu. yd.	11,600	7.50	87,000	
	Excavation (stripping and toe).	Cu. yd.	25,500	.40	10,200	
	Stone revetment	Cu. yd.	63,200	5.00	316,000	
	Gravel filter and toe drain	Cu. yd.	16,000	1.50	24,000	
	Contingencies				174,800	
	Subtotal, east dike				1,310,000	
	Auxiliary dam (spillway):					
	Excavation	Cu. yd.	88,000	3.00	264,000	
	Concrete sill	Job		Lump sum	6,000	
	Contingencies				40,000	
	Subtotal, spillway				310,000	

Cost estimate for the recommended Cave Buttes detention basin, Phoenix, Ariz., and vicinity (including New River)--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
04.	Dam--Continued:					
	Total, Dam					$5,550,000
30.	Engineering and design					620,000
31.	Supervision and administration					320,000
	Total, project first cost to the United States					6,490,000
	NON-FEDERAL COSTS					
	Rights-of-way				$260,000	
	Total, project first cost to local interests					260,000
	Total, project first cost					6,750,000

Cost estimate for the recommended Cave Creek channel, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
09.	Channel improvement:					
	Clearing	Job		Lump sum	$5,000	
	Excavation	Cu. yd.	310,000	$0.35	108,500	
	Concrete, invert	Cu. yd.	5,900	12.00	70,800	
	Concrete, walls	Cu. yd.	25,600	15.00	384,000	
	Cement	Bbl.	47,300	4.25	201,025	
	Reinforcing steel	Lb.	2,500,000	.11	275,000	
	Paved berms	Lin. ft.	20,000	4.60	92,000	
	Subdrainage system	Lin. ft.	19,000	12.00	228,000	
	Contingencies				195,675	
	Total, channel improvement					$1,560,000
30.	Engineering and design					190,000
31.	Supervision and administration					90,000
	Total, project first cost to the United States					1,840,000
	NON-FEDERAL COSTS					
	Rights-of-way				52,000	
	Relocations:					
	Utilities				8,000	
	Total, project first cost to local interests					60,000
	Total, project first cost					1,900,000

Cost estimate for the recommended Union Hills diversion channel, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
09.	Channel improvement:					
	Clearing	Job		Lump sum	$10,000	
	Excavation	Cu. yd.	3,100,000	$0.35	1,085,000	
	Compacted fill	Cu. yd.	100,000	.20	20,000	
	Concrete, walls	Cu. yd.	81,800	15.00	1,227,000	
	Concrete, slab	Cu. yd.	59,200	12.00	710,400	
	Cement	Bbl.	211,600	4.25	899,300	
	Reinforcing steel	Lb.	12,000,000	.11	1,320,000	
	Paved berm	Lin. ft.	52,000	4.60	239,200	
	Contingencies				819,100	
	Total, channel improvement					$6,330,000
30.	Engineering and design					500,000
31.	Supervision and administration					370,000
	Total, project first cost to the United States					7,200,000

Cost estimate for the recommended Union Hills diversion channel, Phoenix, Ariz., and vicinity (including New River)--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	NON-FEDERAL COSTS					
	Rights-of-way				$860,000	
	Relocations:					
	Utilities				10,000	
	Highways and bridges				430,000	
	Total, project first cost to local interests					$1,300,000
	Total, project first cost					8,500,000

Cost estimate for the recommended Dreamy Draw detention basin, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
04.	Dam:					
.1	Main embankment:					
	Clearing and grubbing	Job		Lump sum	$4,000	
	Embankment	Cu. yd.	114,000	$0.60	68,400	
	Scaling	Cu. yd.	1,000	7.50	7,500	
	Excavation	Cu. yd.	7,500	.40	3,000	
	Stone	Cu. yd.	6,800	5.00	34,000	
	Filter material	Cu. yd.	5,600	4.50	25,200	
	Contingencies				27,900	
	Subtotal, main embankment				170,000	
.3	Outlet works	Job		Lump sum	20,000	
.5	Auxiliary dam (dike):					
	Collecting levee	do		do	10,000	
	Auxiliary dam (spillway):					
	Excavation	Cu. yd.	42,000	1.00	42,000	
	Concrete	Job		Lump sum	10,000	
	Contingencies				8,000	
	Subtotal, spillway				60,000	
	Total, dam					$260,000

Cost estimate for the recommended Dreamy Draw detention basin, Phoenix, Ariz., and vicinity (including New River)--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
30.	Engineering and design					$55,000
31.	Supervision and administration					15,000
	Total, project first cost to the United States					330,000
	NON-FEDERAL COSTS					
	Rights-of-way				$130,000	
	Total, project first cost to local interests					130,000
	Total, project first cost					460,000

Cost estimate for recommended Arizona Canal diversion channel, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
09.	Channel improvement:					
	Clearing	Job		Lump sum	$35,000	
	Excavation, channel	Cu. yd.	7,600,000	$0.45	3,420,000	
	Excavation, toe	Cu. yd.	416,000	.35	145,600	
	Embankment	Cu. yd.	123,000	.20	24,600	
	Backfill, toe	Cu. yd.	280,000	.15	42,000	
	Concrete, walls	Cu. yd.	9,400	22.50	211,500	
	Concrete, side slopes	Cu. yd.	13,000	15.00	195,000	
	Concrete, invert	Cu. yd.	26,500	12.00	318,000	
	Cement	Bbl.	81,200	4.25	345,100	
	Reinforcing steel	Lb.	4,530,000	.11	498,300	
	Stone protection	Cu. yd.	319,100	7.00	2,233,700	
	Filter	Cu. yd.	124,000	6.00	744,000	
	Grouting revetment	Cu. yd.	3,800	12.00	45,600	
	Fencing	Lin. ft.	18,600	1.00	18,600	
	Paving	Job		Lump sum	280,000	
	Side drains	do.		do.	25,000	
	Subdrain system	Lin. ft.	7,600	12.00	91,200	
	Contingencies				1,326,800	
	Total, channel improvement					$10,000,000
30.	Engineering and design					840,000
31.	Supervision and administration					560,000
	Total, project first cost to the United States					11,400,000

Cost estimate for recommended Arizona Canal diversion channel, Phoenix, Ariz., and vicinity (including New River)--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	NON-FEDERAL COSTS					
	Rights-of-way				$3,370,000	
	Relocations:					
	Utilities				20,000	
	Highways and bridges				810,000	
	Total, project first cost to local interests					$4,200,000
	Total, project first cost					15,600,000

Cost estimate for the recommended Dreamy Draw channel, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
09.	Channel improvement:					
	Clearing	Job		Lump sum	$5,000	
	Excavation	Cu. yd.	80,000	$0.45	36,000	
	Compacted backfill	Cu. yd.	37,000	.20	7,400	
	Concrete, walls	Cu. yd.	6,200	22.50	139,500	
	Concrete, invert	Cu. yd.	3,800	12.00	45.600	
	Cement	Bbl.	16,000	4.25	68,000	
	Reinforcing steel	Lb.	1,000,000	.11	110,000	
	Paved berms	Lin. ft.	10,500	4.60	48,300	
	Subdrainage system	Lin. ft.	10,500	12.00	126,000	
	Contingencies				84,200	
	Total, channel improvement					$670,000
30.	Engineering and design					110,000
31.	Supervision and administration					40,000
	Total, project first cost to the United States					820,000

Cost estimate for the recommended Dreamy Draw channel, Phoenix, Ariz., and vicinity (including New River)
--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	NON-FEDERAL COSTS					
	Rights-of-way				$15,000	
	Relocations:					
	Utilities				30,000	
	Highways and bridges				35,000	
	Total, project first cost to local interests					$80,000
	Total, project first cost					900,000

Cost estimate for the recommended Skunk Creek channel, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
09.	Channel improvement:					
	Clearing	Job		Lump sum	$10,000	
	Excavation	Cu. yd.	1,700,000	$0.35	595,000	
	Compacted fill	Cu. yd.	700,000	.20	140,000	
	Concrete, walls	Cu. yd.	73,800	15.00	1,107,000	
	Concrete, slab	Cu. yd.	63,000	12.00	756,000	
	Cement	Bbl.	219,200	4.25	931,600	
	Reinforcing steel	Lb.	11,600,000	.10	1,160,000	
	Stone	Cu. yd.	54,000	7.00	378,000	
	Grout	Cu. yd.	7,000	12.00	84,000	
	Filter	Cu. yd.	15,000	6.00	90,000	
	Paved berms	Lin. ft.	34,000	4.60	156,400	
	Contingencies				792,000	
	Total, channel improvement					$6,200,000
30.	Engineering and design					540,000
31.	Supervision and administration					360,000
	Total, project first cost to the United States					7,100,000

Cost estimate for the recommended Skunk Creek channel, Phoenix, Ariz., and vicinity (including New River)
--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	NON-FEDERAL COSTS					
	Rights-of-way				$83,000	
	Relocations:					
	Utilities				7,000	
	Highways and bridges				270,000	
	Total, project first cost to local interests					$360,000
	Total, project first cost					7,460,000

Cost estimate for the recommended New River detention basin, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
04.	Dam:					
.1	Main embankment:					
	Clearing and grubbing	Job		Lump sum	$4,000	
	Diversion and control of water.	do		do	20,000	
	Embankment	Cu. yd.	1,210,000	$0.60	726,000	
	Scaling rock, abutment	Cu. yd.	22,000	7.50	165,000	
	Excavation, inspection trench.	Cu. yd.	28,000	.40	11,200	
	Excavation, stripping	Cu. yd.	32,000	.40	12,800	
	Stone revetment	Cu. yd.	50,000	5.00	250,000	
	Gravel, filter and toe drain.	Cu. yd.	125,000	1.50	187,500	
	Contingencies				223,500	
	Subtotal, main embankment				1,600,000	
.3	Outlet works	Job		Lump sum	200,000	
.5	Auxiliary dam (saddle dike):					
	Embankment	Cu. yd.	68,000	.60	40,800	
	Stone revetment	Cu. yd.	15,000	5.00	75,000	
	Gravel, filter and drain	Cu. yd.	12,000	1.50	18,000	
	Contingencies				26,200	
	Subtotal, saddle dike				160,000	

Cost estimate for the recommended New River detention basin, Phoenix, Ariz., and vicinity (including New River)--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
04. .5	Dam--Continued:					
	Auxiliary dam (spillway):					
	Excavation	Cu. yd.	150,000	$1.00	$150,000	
	Concrete sill	Job		Lump sum	110,000	
	Contingencies				40,000	
	Subtotal, spillway				300,000	
	Total, dam					$2,260,000
08.	Access road	Job		Lump sum		180,000
30.	Engineering and design					340,000
31.	Supervision and administration					120,000
	Total, project first cost to the United States					2,900,000
	NON-FEDERAL COST					
	Rights-of-way				480,000	
	Total, project first cost to local interests					480,000
	Total, project first cost					3,380,000

Cost estimate for recommended New River and Agua Fria River channelization, Phoenix, Ariz., and vicinity (including New River)

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	FEDERAL COSTS					
02.	Relocations:					
.2	Railroad bridge	Job		Lump sum	$190,000	
	Total, relocations					$190,000
09.	Channel improvement:					
	Clearing	Job		Lump sum	35,000	
	Excavation, channel	Cu. yd.	22,900,000	$0.35	8,015,000	
	Excavation, toe	Cu. yd.	800,000	.40	320,000	
	Backfill	Cu. yd.	845,000	.15	126,750	
	Embankment	Cu. yd.	250,000	.20	50,000	
	Stone revetment	Cu. yd.	460,000	7.00	3,220,000	
	Filter	Cu. yd.	135,000	6.00	810,000	
	Grout	Cu. yd.	60,000	12.00	720,000	
	Cement	Bbl.	120,000	4.25	510,000	
	Side drains	Job		Lump sum	20,000	
	Contingencies				1,953,250	
	Total, channel improvement					15,780,000
30.	Engineering and design					900,000
31.	Supervision and administration					930,000
	Total, project first cost to the United States					17,800,000

Cost estimate for recommended New River and Agua Fria River channelization, Phoenix, Ariz., and vicinity (including New River)--Continued

Cost acct. No.	Description	Unit	Quantity	Unit price	Amount	
					Subtotal	Total
	NON-FEDERAL COSTS					
	Rights-of-way				$1,700,000	
	Relocations:					
	Utilities				700,000	
	Highways and bridges				1,000,000	
	Total, project first cost to local interests					$3,400,000
	Total, project first cost					21,200,000

APPENDIX 4 - BENEFITS FROM FLOOD CONTROL

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

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2.	Damage-discharge and damage-frequency curves.
3.	Damage-discharge and damage-frequency curves.
4.	Population curves.

B E N E F I T S F R O M F L O O D C O N T R O L

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

SCOPE

1. This appendix presents supplemental material on the determination of flood frequencies and the evaluation of flood-control benefits from construction of the recommended plan for Phoenix, Ariz., and vicinity (including New River).

FLOCD FREQUENCIES

2. Two stream-gaging stations exist in the area under consideration. Both of these were recently established - one in 1957 on Cave Creek about 1/2 mile upstream from the Arizona Canal and the other in 1960 on the New River at the Black Canyon Highway. No floods have occurred since establishment of these gaging stations.

3. Large floods are known to have occurred along Cave Creek in February 1905 and August 1921; small to medium floods in September 1916, November 1919, January 1922, and August 1943; and minor floods in 1935, 1949, 1951, 1956, and 1957. However, no reliable estimate of discharge is available for any of the floods.

4. A discharge-frequency relationship was therefore developed for Cave Creek on the basis of (a) correlation with the discharge-frequency curve for Queen Creek at Whitlow Ranch Reservoir and (b) a generalized analysis of the floods of record in the area.

5. A discharge-frequency curve has been developed for Queen Creek at Whitlow Ranch Reservoir. This curve is given in the previously completed report on Indian Bend Wash, Arizona, dated April 15, 1962, and reproduced on plate 1 of this appendix.

6. Analysis of the past floods of record indicates that flows equaling or exceeding the capacity of the Arizona Canal (600 c.f.s.) occur about every other year. Since establishment of the gage on Cave Creek, recorded flows approximating the capacity of the Arizona Canal occurred as follows: September 1958, 573 cubic feet per second; August 1959, 540 cubic feet per second; and December 1960, 557 cubic feet per second.

7. Further analysis of the floods of record and their relative magnitude indicates that six floods, the floods of 1905, 1916, 1919, 1921, 1922, and 1943, exceeded a discharge of about 6,000 cubic feet per second. Applying Beard's table of plotting positions, as indicated

in EM 1110-2-1450 and considering that the period of record extends from 1905 to 1962 (a period of 58 years), the indicated plotting position for a flood of 6,000 cubic feet per second is 9.8 times in 100 years.

8. It is estimated that the uncontrolled standard project flood for Cave Creek at Arizona Canal (65,000 c.f.s.) would have the same frequency of occurrence as a standard project flood for Queen Creek at Whitlow Ranch Reservoir (110,000 c.f.s.).

9. A discharge-frequency curve was then drawn for Cave Creek at Arizona Canal using the three points indicated above as guides. A comparison with the Queen Creek curve indicates that it has a steeper slope than that curve. Considering the history of floods in the area, this appears to be reasonable. In addition, results using this curve are more conservative than assuming that the Cave Creek curve is parallel to the Queen Creek curve. The frequency curve for the New River at U.S. Highway 60 bridge was then drawn parallel to the Cave Creek curve, using the standard-project-flood estimates as a basis for comparison of the two curves.

PRESENT AND FUTURE VALUE OF PROPERTY IN THE OVERFLOW AREAS

10. Two estimates were made for property values in each overflow area: the first based on present (1963) development and the second on the average future development over the next 100 years. Estimates of the 1963 values of improvements subject to flood damage were made by use of (a) assessed valuations of the county assessor adjusted to market value of the property, (b) valuation data supplied by local interests, and (c) field inspections and appraisals of the present development in the overflow areas.

11. Estimates of average future values were made principally by considering population, residential, business, and industrial trends in the overflow areas considered. Consideration was also given to the increase in per capita income and level of living over the future and to the availability of space for future expansion.

12. The population growth forecast for the overflow areas is based on data and estimates supplied by the Maricopa County Planning and Zoning Commission and the city of Phoenix and by private interests. Table 1 and plate 4 summarize the actual and estimated population growth during the period 1920 to 2013 for Maricopa County, the city of Phoenix, and the overflow areas considered in this report for Phoenix, Ariz., and vicinity (including New River). Records of population of the overflow areas prior to 1960 are not available. For purposes of this report, population projections were only made to 2013 - 50 years from the present date.

Table 1

Summary of population data for Maricopa County, the State of Arizona, and the overflow areas under consideration, Phoenix, Ariz., and vicinity (including New River), Gila River basin, Ariz. and N. Mex.

Year	Population			
	Maricopa County	City of Phoenix	Overflow areas	
			Cave Creek	Skunk Creek, New River, Agua Fria River
1920	90,000	29,000	.....	.....
1940	186,000	65,000	.....	.....
1950	332,000	107,000	.....	.....
1960	664,000	439,000	.....	.....
1963	800,000	500,000	91,000	2,500
1980	2,000,000	1,220,000	188,000	6,000
2000	5,100,000	3,000,000	201,000	20,000
2013	8,800,000	5,000,000	201,000	36,000

Note. Bases for data as follows: 1920, 1940, 1950, and 1960 - U.S. Census; 1963 through 2013 - (a) county - based on Valley National Bank projections, (b) overflow areas - estimate by U.S. Army Engineer District, Los Angeles.

13. Pertinent information on the estimated growth in the two overflow areas under detailed consideration in this report is given in the following subparagraphs.

(a) Cave Creek overflow area.--Population in the Cave Creek overflow area is estimated to increase by 125 percent over the next 50-year period, as compared to an estimated increase of 900 percent for the city of Phoenix. A more conservative estimate was used for the Cave Creek area because of the greater density of development that now exists in the Cave Creek area, as compared to the density of development for the entire Phoenix area. An analysis of the space requirements for the forecasted growth indicates that there is sufficient vacant land available to accommodate the growth. In addition, a reduction in agricultural acreage will occur.

(b) Valuations of residential, commercial, public, utility, and highway properties will generally follow the population growth.

Industrial property values, however, will increase in line with forecasts made by Western Business Consultants, Inc., as given in the main report under the heading "Occupations and Industries." These forecasts indicate an increase of industrial development of about 85 percent in the 22-year period from 1958 to 1980 and continued growth beyond that date. Railroad property values will increase to reflect the servicing of new industrial plants. The values of agricultural property and of irrigated land will decrease in the future, reflecting the displacement of agricultural land to urban uses.

(c) In addition to the increase in physical properties to be located in the overflow area over the next 100-year period, it is recognized that the gross national product per capita and the per capita income have been increasing steadily. All forecasts of the national economy indicate that these per capita values will continue to increase. In the past, per capita income increases in the Phoenix area have exceeded national rates by a substantial amount. For purpose of this report, it was assumed that the per capita income in the Phoenix area would increase at a rate of 1.5 percent, compounded annually, which is approximately the rate forecast for the United States as a whole.

(d) The values of average future developments were discounted to present-worth amounts by methods established in EM 1120-2-118, appendix II.

(e) The results of this analysis indicate that, over the next 100-year period, the average value of property within the Cave Creek overflow area will be about 120 percent greater than the value of present development.

(f) Skunk Creek-New River-Agua Fria River overflow area.--Population growth in the Phoenix metropolitan area will have a major impact on the economy of the Skunk Creek-New River-Agua Fria River overflow area. As indicated in the main report under "Type and Value of Property in the Overflow Areas," expansion of the Phoenix urban area to this overflow area will occur within about 5 years. Because the density of development along Skunk Creek, the New River, and the Agua Fria Fria River is very low, as compared to the Phoenix metropolitan area, future growth rates for this area will exceed growth rates for the city of Phoenix. An increase of 1,100 percent over the next 50 years was estimated for the Skunk Creek-New River-Agua Fria River area as compared to a forecasted increase of 900 percent for the city of Phoenix.

(g) Property values for the Skunk Creek-New River-Agua Fria River overflow area would generally follow population growth. Residential development would take place to house the forecasted increase in population. Industrial development, which is minor at the present time, would increase in magnitude until it would compare equally, on a percentage basis, with industrial development in the Cave Creek area. Agricultural values will decrease, reflecting the displacement of such land to urban uses.

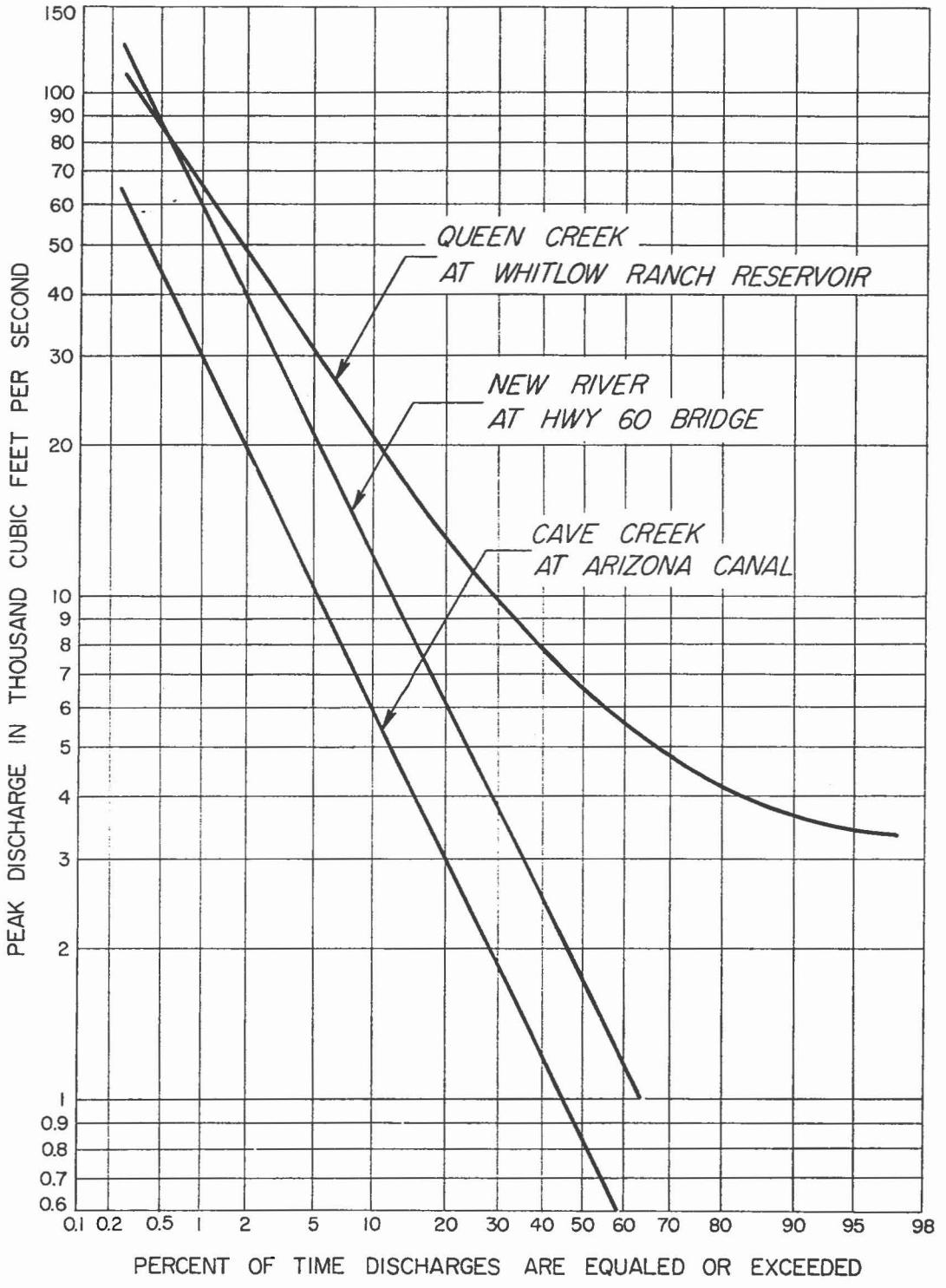
(h) Per capita income increases and present-worth factors were applied to values in the Skunk Creek-New River-Agua Fria River area similar to the application of such factors to values in the Cave Creek area. The results of this analysis indicate that over the next 100-year period the average value of property within the Skunk Creek-New River-Agua Fria River overflow area will be about 10 times the value of present development.

(i) A summary of average future values is given in the main report under the paragraph heading "Type and Value of Property in the Overflow Areas."

DAMAGES FROM FUTURE FLOODS

14. A summary of estimates of damage that would result from future floods of various magnitudes in the overflow areas of Cave Creek, Skunk Creek, the New River, and the Agua Fria River is given in the main report. Curves showing the relationship between peak discharges in cubic feet per second and total damage in dollars under average future conditions is shown on plates 2 and 3. The discharge-damage curves were combined with the proper discharge-frequency curve shown on plate 1 to obtain the damage-frequency curves also shown on plates 2 and 3. The area under the damage-frequency curves represents the estimated average annual damage for the area.

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS



GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

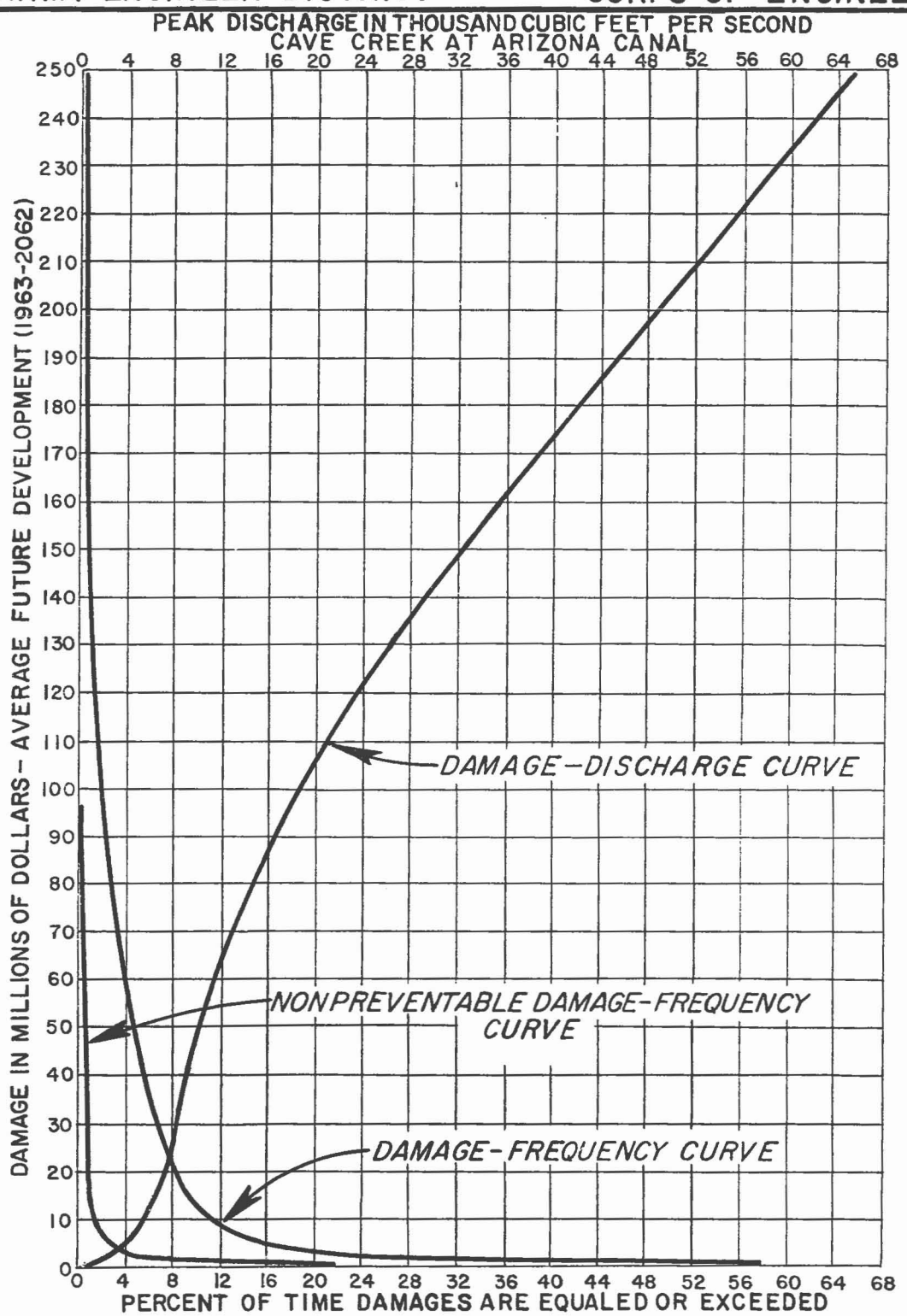
DISCHARGE-FREQUENCY CURVES

CAVE CREEK AND NEW RIVER

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED : JAN. 15, 1964

FILE NO. 203/116 APPENDIX 4 PLATE 1

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS



GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

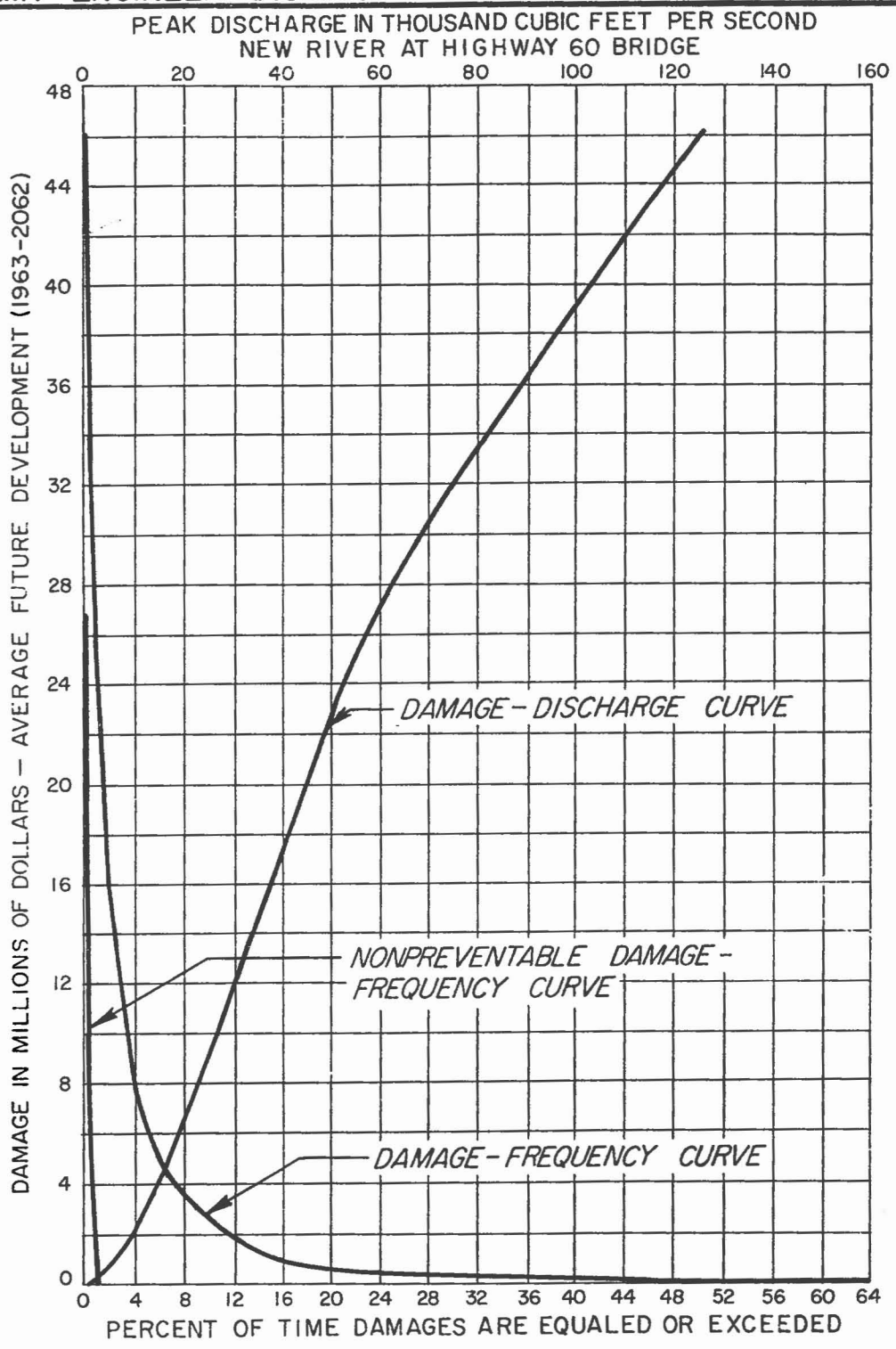
DAMAGE-DISCHARGE AND DAMAGE-FREQUENCY CURVES

CAVE CREEK OVERFLOW AREA

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/117 APPENDIX 4 PLATE 2

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS



GILA RIVER AND TRIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

DAMAGE-DISCHARGE AND DAMAGE-FREQUENCY CURVES

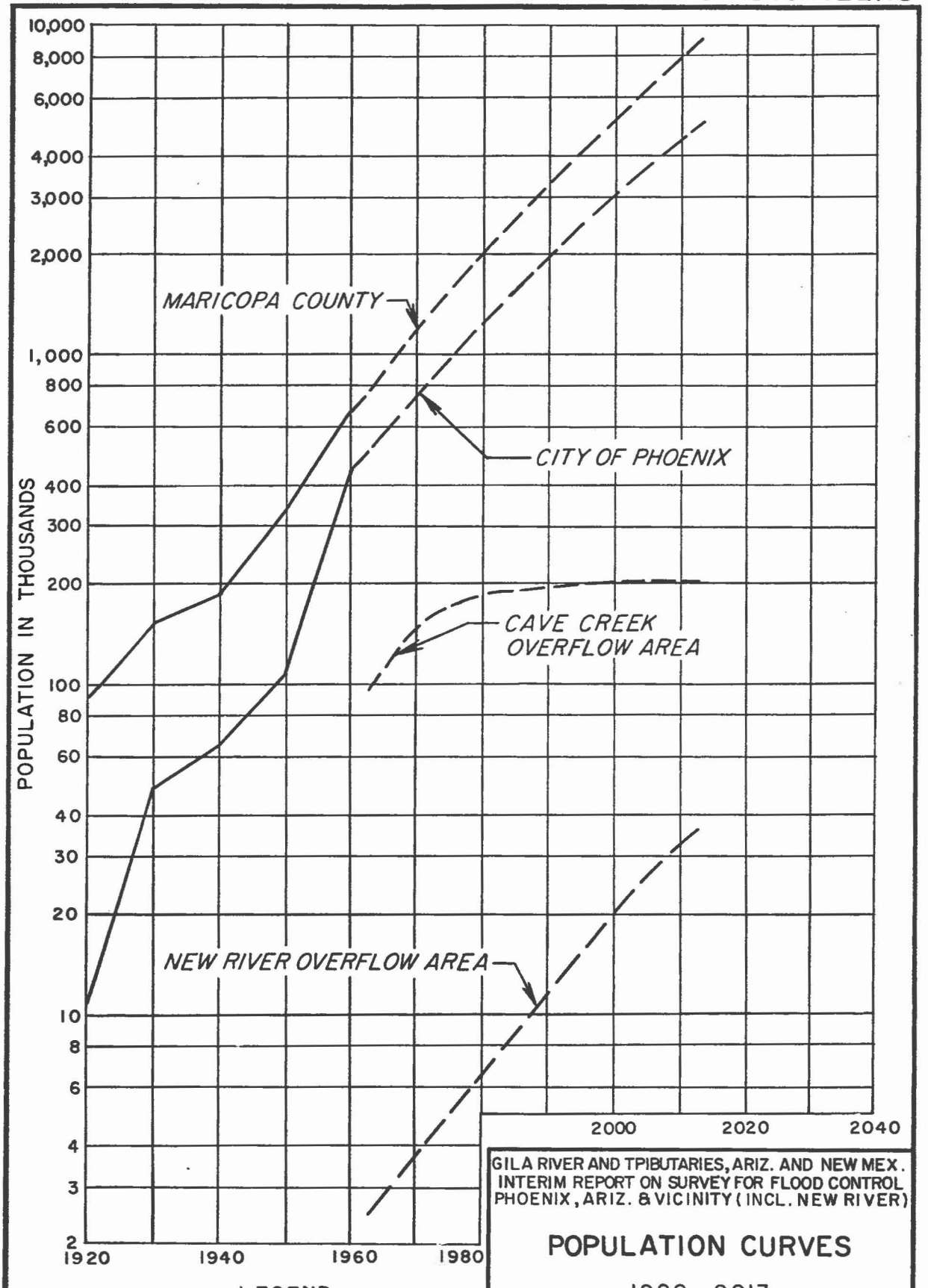
SKUNK CREEK-NEW RIVER-
AGUA FRIA RIVER OVERFLOW AREA

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/118 APPENDIX 4 PLATE 3

U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS



GILA RIVER AND TPIBUTARIES, ARIZ. AND NEW MEX.
INTERIM REPORT ON SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZ. & VICINITY (INCL. NEW RIVER)

POPULATION CURVES

1920 - 2013

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: JAN. 15, 1964

FILE NO. 203/119 APPENDIX 4 PLATE 4

APPENDIX 5 - COMMENTS OF OTHER AGENCIES

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

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SCOPE

This appendix includes the comments of Federal and State agencies on this report. Where pertinent, replies of the U.S. Army Engineer District, Los Angeles, are included.

IN REPLY REFER TO:

Land Operations

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF INDIAN AFFAIRS
Phoenix Area Office
P. O. Box 7007
Phoenix 11, Arizona

Your Reference:
SPLGP-F

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles, California 90017

Dear Sir:

This office has reviewed your Interim Report on Survey for Flood Control, Phoenix, Arizona, and vicinity.

The proposed works will have little or no direct effect on Indian lands. However, the over-all benefits of the project will enhance the economic well being of the entire area including adjacent Indian land. We therefore endorse the proposed project without qualification.

The opportunity to review the report is appreciated.

Sincerely yours,

George W. Madden

ASST. Area Director

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
Pacific Southwest Field Representative
401 Boston Building
Salt Lake City, Utah 84111

December 16, 1963

Colonel Earl C. Peacock
District Engineer, Corps of Engineers
Army Engineer District, Los Angeles
751 South Figueroa Street
Los Angeles, California 90017

Dear Sir:

The following comments are submitted in response to your request of November 18 (SPLGP-F), on the proposed interim report for flood-control, Phoenix, Arizona, and vicinity.

Generally, the proposed program will not seriously affect the management programs of the Bureau of Land Management for the public lands in the area. While a good part of the watershed involved in the program is public domain, most of the construction involves downstream structures in the immediate vicinity of Phoenix, where BLM administers little, if any, lands. A portion of the dams and channels will be located on public land. Some mining claims may also be involved. For example, a 40-acre tract near the airport is leased for a sand and gravel operation; however, no serious problems are anticipated.

Some public lands may be involved at the New River, Cave Buttes, Dreamy Draw, and Adobe structure sites and other small amounts may be located along the New River channel. A status check has been made to determine this. Apparently no application for withdrawal or right-of-way has been filed for the projects. So far as range programs are concerned, the proposed structures will have little or no affect on BLM operations. As we have no intensive range management or conservation programs contemplted for BLM lands in this vicinity, we can foresee no conflicts with current grazing activities.

It is possible that our land disposition programs may be affected indirectly where public lands may be in demand or devoted to such uses as homesites, recreation, etc., and access to them is removed by the

construction of the channels and dikes. Our present planning has not progressed to the point where we can pinpoint this occurring.

Also, in view of our need in this area to expand wildlife habitat and our cooperative ventures with the Arizona State game and fish department, it is our feeling that where it is at all legally possible, deadwater storage should be retained for the benefit of game birds.

Sincerely,

Virgil T. Heath
Representative, Pacific Southwest
Field Committee

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 17, California

SPLGP-F

30 December 1963

Mr. Virgil T. Heath
Pacific Southwest Field Representative
Bureau of Land Management
U.S. Department of the Interior
401 Boston Building
Salt Lake City, Utah 84111

Dear Mr. Heath:

Reference is made to your letter of comment of 16 December 1963 regarding our proposed interim report for flood control, Phoenix, Arizona, and vicinity (including New River).

Your comment is noted regarding the effect of the proposed project on your land disposition programs, and that access to those lands may be removed by construction of the project. If the recommended plan of improvement is authorized, you will be informed, during the detailed design studies, of the definite location of those improvements. At that time, the problems of access to public lands and withdrawal of such lands will be resolved.

You also comment on the need to expand wildlife habitat and the retention of dead-water storage for the benefit of game birds. We agree as to the desirability of incorporating such features into the plan of improvement, if such features can be justified. More detailed studies will be given to enhancement of wildlife habitat in the definite project studies after authorization of the project.

Sincerely yours,

/s/ A. R. MARSHALL
Lt. Col., Corps of Engineers
Deputy District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
[redacted]
AREA V

OFFICE OF
AREA DIRECTOR

224 NEW CUSTOM HOUSE
DENVER, COLORADO 80202

December 12, 1963

Your reference:
SPLGP-F

Earl C. Peacock, Colonel
U. S. Army Engineer District, Los Angeles
Corps of Engineers
751 South Figueroa Street
Los Angeles, California 90017

Dear Colonel Peacock:

The proposed Corps of Engineers "Interim Report on Survey for Flood Control, Phoenix, Arizona and Vicinity (Including New River)," which was submitted with your letter of November 18, has been reviewed and the project area examined by resource engineers of the Bureau of Mines stationed at Tucson. Their report, in which I concur, follows:

The flood control works proposed would be partly in unsettled areas north and northwest of the metropolitan area of Phoenix and partly within builtup city and suburban areas.

In reviewing the project with respect to its effect on mineral resources, the files of the Bureau of Mines were consulted, and a brief field examination was made to verify the present status of mineral exploration in the area.

This letter report deals only with possible loss of potential mineral reserves that might become unavailable because of the proposed construction. Ownership and valuation of the property involved are not considered. It is concluded that the area has a low potential for minerals other than sand and gravel, and that possible loss of reserves because of the project would be negligible.

The construction zone and the drainage basin upstream from planned project works have a long history of mineral exploration, largely unsuccessful, for copper, gold, and other metals. The proposed project would have an effect only on deposits in the immediate construction area. The mineral potential upstream would be unaffected. Even in the construction zone, the few known mineral prospects, with one exception, are on high ground that would remain accessible for exploitation.

The exception is a mercury occurrence in Dreamy Draw in T. 2 N., R. 3 E., and T. 3 N., R. 3 E., northwest of the Phoenix Mountains. Part of the area involved in the proposed Dreamy Draw detention basin and channel is covered by patented or located mineral claims on small, mercury-bearing veins in schist. The deposits have been developed at various times between 1916 and 1947 through underground openings--shafts and tunnels, but no production has been made other than token amounts, perhaps as much as 25 flasks of mercury in all, retorted at the mines.

The deposits are described in Bulletin No. 122 of the Arizona Bureau of Mines, 1927, pp. 44-60, and in U. S. Geological Survey Bulletin 690, pp. 95-110. Two reports in the Tucson files of the Bureau of Mines also deal with the deposits: A confidential U.S.G.S. memorandum report by Max D. Crittenden in 1943, and a U.S.B.M. report by Lincoln A. Stewart in 1947. Both reports were made to evaluate requests of property owners for Government exploration. Both requests were denied on the basis that further work was not warranted.

At least three groups of claims have been located covering most of upper Dreamy Draw and the lower slopes of the Phoenix Mountains. No work is being done currently, all surface buildings and equipment have been removed, and most underground workings are inaccessible. Flood control features would not interfere with future operation of workings on the slopes above Dreamy Draw. Only certain ground in the floor of Dreamy Draw channel would become unavailable for mineral exploration. The major shaft in the area was on the Rico patented group of claims, adjacent to the dry stream bed about $\frac{1}{2}$ mile below the site of the detention basin dam. This shaft has been destroyed, although the dump remains. Concrete foundations nearby mark the sites of a mill and a furnace. Part of the claim area has been used as a trash dump but is now posted by the county to prohibit such use. A gravel road along the draw, Shea Boulevard, has been replaced by Northern Avenue, a hard-surfaced highway on higher ground.

Based on the published mineral reports on the area and on the two confidential reports made by Government examiners in 1943 and 1947, the conclusion reached is that, although mineral occurrences are present locally, no worthwhile deposits other than sand and gravel occur in the area in which construction is planned. The Phoenix area contains many sand and gravel deposits of the same type. Any suitable sand and gravel excavated during the course of the work could be utilized to advantage on the job or stockpiled for future use.

The tenor of mercury mineralization as indicated by several investigations is poor, the reserve potential is low, and the possibility of future profitable mining operations remote. The deposits, therefore, do not appear to be a significant mercury resource.

Yours very truly,

Robert W. Geehan

Robert W. Geehan
Area Director
Area V Mineral Resource Office

REGION SEVEN
ARIZONA
CALIFORNIA
NEVADA
HAWAII

U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
230 N. 1st Avenue
Phoenix, Arizona 85025

January 10, 1964

IN REPLY REFER TO:

07-02.8

U.S. Army Engineer District
Los Angeles
Corps of Engineers
751 South Figueroa Street
Los Angeles, California 90017

Attention: Chief of Engineering Division

Dear Sir:

Reference is made to your telegram of January 10, 1964, concerning our comments on your interim report for flood control, Phoenix, Arizona, and vicinity (including New River).

We have no comments to add to that already carried in Paragraph 103 of the report wherein Federal-aid Highway Funds are stated to be ineligible for use on highways or bridges built or reconstructed as part of the local contribution to financing the Project.

Sincerely yours,

W. H. Baugh

W. H. BAUGH
Division Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGION 3
BOULDER CITY, NEVADA

IN REPLY
REFER TO: 3-700

DEC 13 1963

Your reference:
SPLGP-F

District Engineer
U. S. Army Engineer
District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California 90017

Dear Sir:

We have reviewed the Interim Report on Survey for Flood Control, Phoenix, Arizona and Vicinity (Including New River) transmitted by your letter of November 18, 1963, and have the following general comments:

The recommended plan of improvements would alleviate a serious local flood problem within the rapidly growing Phoenix metropolitan area. It would protect the overflow areas along Dreamy Draw, Cave Creek, Skunk Creek, the New River, the Agua Fria River, and several other unnamed washes. As a result of this protection, optimum development of the land by commercial and residential interests could be realized.

The Granite Reef Aqueduct of the Central Arizona Project, proposed by the Bureau of Reclamation, crosses three of the drainage basins in which the subject plan has proposed features. The aqueduct alignment now under consideration would pass just upstream from the Lower New River Detention Basin, directly through the Adobe Detention Basin, and downstream from the Cave Buttes Detention Basin Dam site.

These proposed flood control facilities could be adapted for multiple-purpose use with mutual advantages for the Central Arizona Project Aqueduct facilities, the future municipal water supply treatment and distribution facilities of the city of Phoenix supplied from the Central Arizona Project, and recreation plans of the Maricopa County Parks and Recreation Department.

In recent meetings between Corps of Engineers and Bureau of Reclamation personnel, coordination of common planning studies has been very satisfactory. When the Central Arizona Project Aqueduct plans are firmed up, it is anticipated that any conflict in location between Central Arizona Project features and the flood control features will be adjusted and the best over-all plan adopted by all interested parties.

We appreciate the opportunity to comment on the subject report.

Sincerely yours,

Acting for
A. B. West
Regional Director

In duplicate

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO

December 16, 1963

Air Mail

District Engineer
Corps of Engineers, U. S. Army
Box 17277 Foy Station
Los Angeles, California

Dear Sir:

Your letter of November 19, 1963, referenced SPLGP-F, requested our comments concerning your proposed interim report for flood control, Phoenix, Arizona, and vicinity (including New River).

As you are aware, this Bureau in cooperation with the Arizona Game and Fish Department has investigated the project in the light of the latest project information available from your office. Enclosed for your review and comment are two copies of a draft of our report for the project.

Since we do not anticipate any major changes in the draft of the report before it is released in final form, we trust the draft will serve your needs at the present time. It is planned to issue the report as soon as we have received the concurrence of the Arizona Game and Fish Department.

If you have comments concerning the draft of the report, we would appreciate receiving them by December 27, 1963.

Sincerely yours,

Lewis R. Garlick
Acting Regional Director

Enclosures 2

cc:
Director, Arizona Game and Fish Department, Phoenix, Arizona
Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Phoenix, Arizona

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Bureau of Sport Fisheries and Wildlife
Albuquerque, New Mexico

December 16, 1963

AIR MAIL

Mr. Robert J. Smith, Director
Arizona Game and Fish Department
105 State Office Building
Phoenix, Arizona

Dear Mr. Smith:

Enclosed for your review and comment are two copies of a draft of our report concerning the Corps of Engineers' Phoenix, Arizona, and Vicinity (Including New River) Flood Control Project.

Since the Corps of Engineers has indicated they are planning to issue their report at an early date, we are striving to release our report as soon as possible. It would be appreciated if we could receive your comments concerning the draft of our report by December 27, 1963. If the report meets with your approval, a letter of concurrence would be appreciated.

Sincerely yours,

Lewis R. Garlick
Acting Regional Director

Enclosures 2

cc:
District Engineer, Corps of Engineers, U.S. Army, Los Angeles, California
Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Phoenix, Arizona

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO

January 17, 1964

District Engineer
Corps of Engineers, U. S. Army
P. O. Box 17277, Foy Station
Los Angeles, California

Dear Sir:

This letter constitutes the Bureau of Sport Fisheries and Wildlife report on fish and wildlife resources in relation to development of Phase B of the proposed Phoenix, Arizona, and Vicinity (including New River) Flood Control Project and supersedes our preliminary report on the project dated December 10, 1959. This report has been prepared under the authority and in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) in cooperation with the Arizona Game and Fish Department and is intended to accompany your project survey report. Concurrence of the Arizona Game and Fish Department is expressed in Director Robert J. Smith's letter dated January 7, 1964, copy of which is enclosed.

The Phoenix and Vicinity (including New River) Flood Control Project is a portion of the Corps of Engineers flood control survey of the Gila River Basin, Arizona and New Mexico. Conducted pursuant to the Flood Control Act approved June 28, 1938 (52 Stat. 1215), the survey of the Gila River Basin is being covered by means of interim reports, review reports, and a final comprehensive report. To date, seven interim reports and three review reports have been submitted to Congress. In addition, four interim reports, including one embodying the plan considered in the ensuing report, are in preparation.

The Phoenix, Arizona, and Vicinity (including New River) Flood Control Project comprises a comprehensive plan for flood control in the Phoenix metropolitan area in Maricopa County, Arizona. The comprehensive plan is being developed in five phases designated A through

E. Phase A will consist of channel improvements on Indian Bend Wash from the Arizona Canal to the Salt River in and adjacent to Scottsdale, Arizona. The Indian Bend Wash development was the subject of a Corps of Engineers' Interim Report on Survey for Flood Control, Indian Bend Wash, Arizona, dated April 15, 1962, and an appended Bureau of Sport Fisheries and Wildlife report dated August 14, 1961. Phase B is considered in the ensuing report. Phases C, D, and E, comprising developments in the Glendale-Maryvale-South Phoenix Area, Maxwell Reservoir and the Salt River, and Indian Bend Wash upstream from the Arizona Canal, respectively, will be presented in future reports.

Principal features of Phase B will be the construction of four floodwater detention basins having a combined capacity of 88,150 acre-feet, construction of 22.75 miles of diversion channels, and channelization of 29.1 miles of river bed. Dreamy Draw detention basin will be located in northeast Phoenix. Cave Buttes, Adobe, and New River detention basins will be located on Cave Creek, Skunk Creek, and New River, respectively, and will be situated a few miles north and northwest of Phoenix. Dreamy Draw is tributary to Cave Creek which in turn is tributary to the Salt River in south-central Phoenix. Skunk Creek is a tributary of New River which in turn is a tributary of the Agua Fria River. The Agua Fria River enters the Gila River about 4 miles below the Gila River-Salt River junction near Avondale, Arizona.

When completed and in operation the detention basins, diversion channels, and streambed channels will form an interconnected system designed to retain floodwaters for later release, divert upper Cave Creek and Dreamy Draw flood flows into the Agua Fria River drainage, and provide increased channel capacity for safe passage of flood flows. Thus, the Phase B developments will provide a large measure of protection to portions of metropolitan Phoenix from floods originating in the major drainages north and northwest of Phoenix. Pertinent engineering data are summarized in Table 1.

Table 1. Pertinent Data, Phase B Developments,
Phoenix, Arizona, and Vicinity (including New River) Flood Control Project

Unit	Length (miles)	Capacity (second-feet)	Capacity at Spillway Crest (acre-feet)	Surface Area at Spillway Crest (acres)	Pool Drain Conduit Capacity (second-feet)
Channels					
Cave Creek Channel	3.6	6,000	-	-	-
Skunk Creek Channel	6.5	24,400-41,400	-	-	-
Dreamy Draw Channel	3.5	100-1,150	-	-	-
New River - Agua Fria River Channel	15.5	53,400-74,000	-	-	-
Arizona Canal Diversion Channel	13.0	1,150-18,500	-	-	-
Union Hills Diversion Channel	9.75	2,000-15,000	-	-	-
Detention Basins					
Cave Buttes Detention Basin	-	-	28,800	825	5,400
Dreamy Draw Detention Basin	-	-	450	30	100
New River Detention Basin	-	-	39,500	1,740	1,000
Adobe Detention Basin	-	-	19,400	1,050	2,000

The Phoenix, Arizona, and Vicinity (including New River) Flood Control Project area is located in a desert environment. Precipitation in the project area averages about 7 inches most of which falls during two rainy seasons, summer and winter. Summer rains frequently are of the local thunderstorm type. Heavy amounts of precipitation may strike scattered, localized areas in a matter of minutes giving rise to flash floods. Winter rains tend to be more widespread, of longer duration, and gentle. Streamflows in project streams are intermittent. The average temperature in the project area is about 70 degrees Fahrenheit while the relative humidity averages about 30 percent. More than 750,000 people live in the Phoenix metropolitan area and the population is burgeoning.

FISH

Without the Project

Because of the intermittent character of streamflow in project streams, fish habitat and fish resources are nonexistent.

With the Project

Present plans provide for ungated outlet works in each of the floodwater detention structures. No storage for water conservation will be included in the floodwater detention reservoirs; hence, no fish habitat will be available with the project. Construction and operation of the project will result neither in losses nor benefits to fish resources and fishing.

WILDLIFE

Without the Project

Construction of project features will affect wildlife habitat in and adjoining portions of Dreamy Draw, Cave Creek, Skunk Creek, New River, and Agua Fria River. Riparian and river bottom perennial vegetation consists principally of mesquite, palo verde, hackberry, ironwood, bursage, baccharis, and various species of cacti. During rainy periods, the normally bare soil between perennial trees and shrubs may be covered with a great variety of ephemeral grasses and forbs.

Principal wildlife species present in the project area include Gambel's quail, white-winged dove, mourning dove, and cottontail. A few mule deer and javelina are present in the vicinity of New River and Adobe damsties.

Upland-game hunting occurs in the project area at present but, because of encroaching urbanization, it is believed that future hunting would be insignificant. However, the river bottom and riparian vegetation would continue to provide good dove-nesting habitat and would contribute to overall hunting success in Arizona.

With the Project

Clearing of perennial vegetation in the detention basins and in the stream channels downstream from the floodwater detention basins will result in a loss of valuable dove-producing habitat. Although effects on hunting in the project area will be insignificant, project-caused habitat losses will contribute to overall hunting losses in Arizona. More detailed project information and additional field investigation would be required to evaluate fully the extent of dove population losses and related hunting losses resulting from project-caused habitat attrition.

Dove-nesting habitat losses will be compensated in part by increased amounts of wildlife food plants in the floodwater detention basins. Intermittent flooding of the basins will create ideal conditions for the growth of food-producing grasses and forbs.

Thus, development and operation of the project will result in wildlife habitat losses. No hunting benefits will be realized.

DISCUSSION

Rapid expansion of population in the Phoenix metropolitan area, coupled with an ever-present shortage of fishing waters, has created a growing unfulfilled demand for additional fishing areas. Construction of floodwater detention dams and basins in the Phoenix area offers an excellent opportunity for enhancement of local fishing. The Arizona Game and Fish Department has expressed great

interest in multipurpose development of one or more of the floodwater detention basins to include storage for fishery pools. Studies by the Arizona Game and Fish Department have indicated that of the four proposed detention basin sites, Adobe, Cave Buttes, and Lower New River sites appear to be the most feasible for inclusion of fishery pools. Additional investigation will be required before specific recommendations can be made concerning fishery pools at these sites.

Inclusion of a fishery pool at Cave Buttes will be more than justified on the basis of fishing use should analysis of additional hydrologic and engineering data prove such development feasible. Surveys by the Arizona Game and Fish Department on existing reservoirs in Arizona indicate that a fishery pool at Cave Buttes could receive in excess of 1,000 man-days of fishing per surface acre annually. Minimum pools at Adobe and Lower New River detention basins also could provide additional fishery benefits.

Every effort should be made to minimize the destruction of riparian and stream-bottom habitat during project construction. Consonant with project construction needs, trees and shrubs should be left undisturbed wherever possible.

RECOMMENDATIONS

It is recommended:

1. That additional study be made by the Corps of Engineers, in cooperation with the Arizona Game and Fish Department, to determine the feasibility of including provision for future storage in Adobe, Cave Buttes, and Lower New River detention basins for development of fishery pools.

2. That project construction planning make provision for minimum disturbance of trees and shrubs wherever possible.

CONCLUSIONS

Construction and operation of the Phoenix, Arizona, and Vicinity (including New River) Flood Control Project will have no effect on Arizona fish resources but will result in a minor loss of dove producing habitat.

The possibility exists that the proposed Adobe, Cave Buttes, and Lower New River detention basins could be modified to include storage for fishery pools. Additional investigation, as proposed in Recommendation No. 1, will be needed to determine the feasibility of fishing lakes at these sites. Effectuation of Recommendation No. 2 will minimize wildlife habitat losses during project construction.

This report is based on project information made available November 19, 1963. Any modification in project plans should be brought to the attention of the Bureau of Sport Fisheries and Wildlife and the Arizona Game and Fish Department.

Sincerely yours,

John C. Gatlin

John C. Gatlin
Regional Director

Enclosure

Copies (10)

Distribution:

(2) Director, Arizona Game and Fish Department, Phoenix, Arizona
(2) Chairman, Board of Directors, Maricopa County Flood Control District, Phoenix, Arizona
(2) Regional Director, Bureau of Reclamation, Region 3, Boulder City, Nevada
(2) Regional Director, National Park Service, Southwest Region, Santa Fe, New Mexico
(2) Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Phoenix, Arizona

PAUL FANNIN
Governor

Commissioners

HARRY FUNK PRESCOTT
LEE HOVER PHOENIX
O. M. SIZER CLIFTON
C. J. MANTLE TUCSON
M. N. FORMAN YUMA

ARIZONA GAME & FISH DEPARTMENT
State Office Building · Phoenix 7, Arizona · 271-4295

• ROBERT J. SMITH Director WENDELL SWANK Assistant Director

January 7, 1964

Regional Director
Fish & Wildlife Service
Bureau of Sport Fisheries & Wildlife
P. O. Box 1306
Albuquerque, New Mexico

Dear Sir:

We appreciate the opportunity to review and comment on the draft of your report concerning the Corps of Engineers' Phoenix, Arizona, and Vicinity (Including New River) Flood Control Project.

Our Department concurs in the proposals in that the draft recommends additional studies be made to determine the feasibility of including provision for storage. The project comments of our letter dated December 9, 1963, to the District Engineer, Corps of Engineers, Los Angeles, pointed out our desire for such investigations.

Thank you for the opportunity to review and comment on this report.

Sincerely,

R. J. Smith, Director

John P. Russo

By: John P. Russo
River Basin Supervisor

JPR:ms

cc: District Engineer, Corps of Engineers, U. S. Army, Los Angeles, California
Field Supervisor of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Phoenix, Arizona

R. 3/25/64

EDMUN . BROWN
GOVERNOR OF
CALIFORNIA

GO FISHER
ADMINISTRATOR
RESOURCES AGENCY

ADDRESS REPLY TO
P. O. Box 388
Sacramento 2, Calif.

LIAM E. WARNE
Director of
Water Resources

. ABBOTT GOLDBERG
Chief Deputy Director

REGINALD C. PRICE
Deputy Director Policy

NEELY GARDNER
Deputy Director
Administration

ALFRED R. GOLZÉ
Chief Engineer

THE RESOURCES AGENCY OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

1120 N. STREET, SACRAMENTO

DEC 19 1963

District Engineer
U. S. Army Engineer District
Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Dear Sir:

Your preliminary "Interim Report on Survey for Flood Control, Phoenix, Arizona, and Vicinity (including New River), (With Appendixes)," dated November 15, 1963, was received on November 21, 1963, for informal review and comment. Our comments are presented in the following paragraphs.

According to the report, the recommended project would provide for the construction of: (1) four dams, one each on Cave Creek, Skunk Creek, New River, and Dreamy Draw; (2) the Union Hills and Arizona Canal diversion channels; and (3) the Cave Creek, Dreamy Draw, Skunk Creek, New River, and Agua Fria River channel improvements. All the streams involved are within the drainage area of the Gila River which is tributary to the Colorado River near Yuma, Arizona.

These improvements would be constructed on or along the above-named streams or their tributaries for flood control only, at a total estimated first cost of $70,000,000. It is noted that no storage for water conservation, water-based recreation, or power development is to be included in the project. Based on available information, the interest of the State of California in the Colorado River would not appear to be prejudiced by the proposed developments, as they would not appreciably affect the Colorado River water supply.

The opportunity to review your report is appreciated.

Sincerely yours,

William E. Warne

Director

cc: Mr. Dallas Cole, Chief Engineer
Colorado River Board of California
909 So. Broadway - Room 230
Los Angeles 15, California

R.3/25/64

I. J. DOWD
CHAIRMAN AND COLORADO RIVER COMMISSIONER
IMPERIAL IRRIGATION DISTRICT

RED W. SIMPSON
SAN DIEGO WATER AUTHORITY

OSEPH JENSEN
THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

HAROLD F. PELLEGRIN
EXECUTIVE SECRETARY

WALTER BOLLENBACHER
PALO VERDE IRRIGATION DISTRICT

SAMUEL B. NELSON
DEPARTMENT OF WATER AND POWER, CITY OF LOS ANGELES

RAYMOND R. RUMMONDS
COACHELLA VALLEY COUNTY WATER DISTRICT

DALLAS E. COLE
CHIEF ENGINEER

STATE OF CALIFORNIA

Colorado River Board of California

909 SOUTH BROADWAY
LOS ANGELES 15

December 13, 1963

Colonel Earl G. Peacock
District Engineer
U.S. Army Engineer District
P. O. Box 17277, Foy Station
Los Angeles 17, California

Colonel Peacock:

This is in reference to your letter of November 19, 1963, which transmitted a draft copy of an interim report on a proposed flood control plan for Phoenix, Arizona and vicinity for our informal review and comment.

We note that a comprehensive five-phase flood control plan has been developed as a framework for all flood control work in the area and that the instant report is directed to the Phase "B" portion of the plan. The proposed development for Phase "B", as recommended by your report, would be essentially single purpose in nature and limited to flood control, but subject to certain conditions some conservation and recreation features could be added at the desire of local interests.

The proposed development does not appear to prejudice the interests of California and its agencies in and to the Colorado River.

The receipt of the report and opportunity to review and comment on it are appreciated.

Dallas E. Cole

Dallas E. Cole
Chief Engineer

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 17, California

SPLGP-F 30 December 1963

Regional Director
Bureau of Sport Fisheries and Wildlife
Fish and Wildlife Service
U.S. Department of the Interior
P.O. Box 1306
Albuquerque, New Mexico

Dear Sir:

Reference is made to your letter of 16 December 1963, inclosing two copies of a review draft of your report on fish and wildlife resources in relation to the development of phase B of the flood-control project for metropolitan Phoenix, as proposed in our draft copy of the interim report for flood control for Phoenix, Arizona, and vicinity (including New River).

We note your agreement that the proposed improvements would provide a large measure of flood protection to portions of metropolitan Phoenix. You indicate that the construction and operation of the project would result neither in losses nor benefits to fish resources and fishing, but would result in some wildlife-habitation losses.

You mention that the Arizona Game and Fish Department has expressed great interest in multiple-purpose development of one or more of the detention basins to include storage for fishery pools. You indicate, however, that additional investigation would be required before specific recommendations can be made concerning fishery pools at those sites.

Your recommendation that project construction planning make provision for minimum disturbance of trees and shrubs wherever possible will be given serious consideration in later studies, provided the project is authorized.

This office gave consideration to development of fish and wildlife and recreation facilities at the proposed reservoir sites. We found that because of the low average annual yield, the high evaporation, and the large infiltration losses, fish and wildlife or recreation facilities that could be developed would be minor and probably could not be justified.

In addition, the Granite Reef aqueduct of the Central Arizona project, proposed by the Bureau of Reclamation, crosses New River, Skunk Creek, and Cave Creek in the vicinity of the proposed detention basins. A definite location for this aqueduct has not been determined and all features of the Bureau project have not been firmed. With the importation of Colorado River water to the area, the proposed detention basins probably could be adapted for multiple-purpose use with mutual advantages for the Central Arizona project aqueduct facilities, the future municipal water supply treatment and distribution facilities of the city of Phoenix supplied by the Central Arizona project, recreation plans of the Maricopa County Parks and Recreation Department, and fish and wildlife facilities to be developed jointly with your office and the Arizona Game and Fish Department.

This office has not made further studies of fish and wildlife and recreation development under present water supply conditions because of: (1) the apparent minor aspect of a fish and wildlife and recreation program under conditions whereby water supplies would be limited to the natural flows of the streams involved; (2) the probability that importation of water from the Colorado River under the Central Arizona project would enhance the opportunity to develop fish and wildlife and recreation resources; and (3) the inability to develop detailed plans utilizing Colorado River water until firm plans are developed by the Bureau of Reclamation. Addition of fish and wildlife and recreation facilities would not appreciably change the overall conclusions of the report. However, you can be assured that if the Phoenix project is authorized for construction, detailed consideration will be given to fish and wildlife and recreation aspects in the definite project studies, to assure that maximum development at the proposed detention basins is achieved.

Sincerely yours,

/s/ A. R. MARSHALL
Lt. Col., Corps of Engineers
Deputy District Engineer

85-Gila River
W/A 61

FEDERAL POWER COMMISSION
REGIONAL OFFICE
555 BATTERY STREET, ROOM 415
SAN FRANCISCO 11, CALIF.

AIR MAIL

December 17, 1963

Colonel Earl C. Peacock
U.S. Army Engineer District
Corps of Engineers
751 South Figueroa Street
Los Angeles, California 90017

Dear Colonel Peacock:

We have made a brief review of your proposed "Interim Report on Survey for Flood Control, Phoenix, Arizona, and vicinity (including New River), Gila River Basin, Arizona and New Mexico", a copy of which was received with your letter of November 18, 1963.

Our review indicates that the recommended flood control improvements would consist of (1) four detention basins, which would be empty at all times except during flood periods; (2) several diversion channels, channel improvements or channelization work.

Since little streamflow occurs at any of the recommended damsites, except during and immediately following periods of heavy rainfall, and since the proposed detention basins will be empty except when storing floodwaters, the development of hydroelectric power in connection with the proposed improvements would not be economically feasible.

We appreciate the opportunity to review and comment on your proposed interim report. We would like to have a copy of your final report when it becomes available.

Sincerely yours,

M. Boyd Austin

M. Boyd Austin
Regional Engineer

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
SOUTHWESTERN REGION
517 GOLD AVENUE, SW
ALBUQUERQUE, NEW MEXICO

January 10, 1964

IN REPLY REFER TO
3510

Colonel Earl G. Peacock
District Engineer
Corps of Engineers
U. S. Army Engineer District
Los Angeles, California

Dear Colonel Peacock:

We have reviewed the preliminary Interim Report on Survey for Flood Control, Phoenix, Arizona, and Vicinity (including New River).

The proposed structural improvements are in excess of ten miles below the nearest point on the Tonto National Forest boundary, and will have no direct impact on either the Tonto or Prescott Forests.

We find that approximately 30 percent of the drainage area above the proposed flood control structures is within the Tonto and Prescott National Forests. Our management of these lands is a vital part of the overall flood prevention effort.

Land management programs on the National Forest lands within the watershed are being accelerated to the extent of available funds. The acceleration of these programs to improve the vegetative cover condition will reduce the flood hazard by increasing infiltration and retention of precipitation. Erosion and subsequent sedimentation of downstream structures will also be reduced. Thus, our management efforts on the upper reaches of the watershed will enhance the value of the proposed flood control project.

The Forest Service will continue to give consideration to flood prevention when making administrative and management decisions affecting the multiple uses on the watersheds land within the National Forests.

Sincerely yours,

FRED H. KENNEDY
Regional Forester

By James G. Smith

2cc- Kirk Sandals

5-26

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
345 MIDDLEFIELD ROAD
MENLO PARK, CALIFORNIA
DAVENPORT 5-6761

January 10, 1964

Colonel Earl G. Peacock
District Engineer
Corps of Engineers
751 South Figueroa Street
Los Angeles, California 90017

Dear Colonel Peacock:

The hydrologic aspects of the Interim Report for Flood-Control, Phoenix, Arizona, and vicinity (including New River), have been reviewed and are deemed to be satisfactory. As noted in the report, runoff and sediment data in the region covered by the report is very scanty--almost non-existent. The method of analysis used in the report is probably the best that could be applied and the results obtained appear to be reasonable.

Very truly yours,

R. Stanley Lord

R. Stanley Lord
For W. W. Hastings
Division Hydrologist
Pacific Coast Area

HOUSING AND HOME FINANCE AGENCY
OFFICE OF THE REGIONAL ADMINISTRATOR
989 Market Street
San Francisco 3, California

REGION VI

DEC 1 9 1963

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles, California 90017

Dear Sir:

We have examined your Interim Report, Phoenix, Arizona and vicinity, the subject of your letter SPLGP-F, November 18, 1963. This Agency has no projects at present which would be adversely affected by the flood control project proposed for that locality.

Sincerely yours,

Paul Emmert
Regional Director,
Community Facilities

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

IN REPLY REFER TO:

Southwest Region
Santa Fe, New Mexico

DEC 3 1963

District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles, California 90017

Dear Sir:

Thank you for the opportunity given us in your letter of November 18, File No. SPLGP-F, to review and comment on your proposed interim report for flood-control, Phoenix, Arizona, and vicinity.

We were pleased to learn that although water -based recreation is not a purpose of the project some recreational development (at non-project cost) and use of the project area could be made by local interests.

It is very probable that each project feature will destroy or damage archeological sites. Therefore, if the project is authorized, arrangements for an archeological survey and necessary salvage will be made by the National Park Service.

Sincerely yours,

Norman B. Herkenham

Norman B. Herkenham
Acting Assistant Regional Director,
Resource Planning

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

PUBLIC HEALTH SERVICE
447 Federal Office Building
San Francisco, California
94102

17 December 1963

Colonel Earl G. Peacock
District Engineer
Corps of Engineers
751 South Figueroa Street
Los Angeles, California 90017

Dear Colonel Peacock:

Enclosed as requested are our comments on the Public Health Aspects of the "Interim Report on Survey for Flood Control Phoenix, Arizona and Vicinity (including New River)."

Thank you for giving us the opportunity to comment on this proposed project.

Sincerely yours,

Paul W. Eastman
Regional Program Director
Water Supply & Pollution Control

Enclosure

cc: Krause
Rainey
Marx

REPORT ON

THE PUBLIC HEALTH ASPECTS

OF THE

INTERIM REPORT ON

SURVEY FOR FLOOD CONTROL

PHOENIX, ARIZONA AND VICINITY

(INCLUDING NEW RIVER)

FOR THE

U. S. ARMY CORPS OF ENGINEERS

PREPARED BY

THE U. S. PUBLIC HEALTH SERVICE

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

REGION IX, SAN FRANCISCO, CALIFORNIA

DECEMBER 1963

PUBLIC HEALTH ASPECTS
of the
INTERIM REPORT ON
SURVEY FOR FLOOD CONTROL
PHOENIX, ARIZONA AND VICINITY
(INCLUDING NEW RIVER)

U. S. Army Corps of Engineers

The Corps of Engineers recommends construction of four dams and channel improvement on Cave Creek, Skunk Creek, the New River, and Dreamy Draw and two diversion channels (Union Hills and Arizona Canal). No water conservation, power development, or water-based recreation is included in the plan. Local interests could modify the plan to include some use of flood flows for water recharge and land-based recreational developments.

SANITARY ENGINEERING

Water Supply

No water conservation benefits are planned, although some replenishment of the ground water basin could be developed at a later date. A benefit would result from the increased flood control since the chance of water supply wells being contaminated is decreased. Contamination of the water system could result during relocation of water mains unless precautions are taken. Any wells that must be abandoned should be sealed to protect the ground water supply and to eliminate the chance of persons falling into them.

Sewage and Industrial Waste Disposal

The recommended plan would decrease the likelihood of sewage and industrial waste facilities being flooded and is therefore advantageous.

WATER POLLUTION CONTROL

The existing stream beds are dry except during times of flood runoff and since no wastes are discharged into the stream bed there is no reason to provide water quality control flows. The proposed project would reduce the quantity of sediment carried into the area of the flood plain.

SANITATION

Any local development of recreation facilities in the future should provide for water supply and sanitation facilities which meet the requirements of the Local Health Department.

VECTOR CONTROL

This vector evaluation is based on a review of the Corps of Engineers' report entitled "Interim Report on Survey for Flood Control, Phoenix, Arizona and Vicinity (including New River)" dated November 15, 1963.

Anticipated Effects of the Proposed Project on Vector Problems

Mosquitoes are the principal vectors which might be affected by the proposed project. Several species of mosquitoes of public health importance including Culex tarsalis and Culex quinquefasciatus, recognized vectors of encephalitis, and the voracious Aedes vexans may be produced in large numbers in the area of the proposed project when suitable aquatic habitats are present. Basic information concerning pertinent biological characteristics of these mosquitoes is given in Appendix A.

Encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the area of the proposed project. Records of the U. S. Department of Agriculture show that equine encephalitis cases occurred in Maricopa County during 16 years of the 17-year period 1939 through 1955 for which records are available. According to the Arizona State Department of Health, 5 human and 25 equine encephalitis cases occurred in Maricopa County during 1960. Additional information concerning the public health and socio-economic importance of mosquito and other vector problems associated with water resource developments is presented in Appendix B.

The reduction in flooding of lowland areas expected from the proposed flood control project should result in a reduction in natural aquatic habitats favorable for the production of mosquitoes and certain other insects of public health importance. On the other hand, certain project elements may result in the development of man-made aquatic habitats favorable for the production of mosquitoes and other aquatic vectors. Of particular significance would be water spreading areas which retain water for periods of 5 days or longer during the mosquito breeding season. By making provisions for the prevention and control of man-made vector sources, the overall benefits of the project can be greatly increased.

Responsibility for Vector Control

Responsibility for vector prevention and control is normally associated with land ownership or operating rights. Therefore, the agency, group, or individuals responsible for various aspects of the proposed project should be prepared to accept full responsibility for the prevention and control of vector problems resulting from the design, construction, operation, or maintenance of the project.

ACCIDENT PREVENTION

Falls into the deeper rectangular channel sections could result in serious injury and precautions should be taken to exclude the public, particularly children, from access to the sides of the channel.

RECOMMENDATIONS

Sanitary Engineering

1. Precautions should be taken during relocation of water mains to avoid contamination of the water system.

2. Wells that are abandoned should be sealed to protect persons from falling into them and to prevent contamination of the ground water supply.

3. Public access to the sides of deep rectangular channels should be restricted in order to reduce the likelihood of falls into the channel.

Vector Control

In order to minimize public health hazards, every possible effort should be made to avoid creating conditions which will increase populations of mosquitoes and other arthropods of public health importance. It is recommended that the following principles and practices be adhered to in the design, construction, operation, and maintenance of the proposed project.

A. Channel Improvements

1. Material excavated from channels and the detention basin should be disposed of in such a way that it will not result in ponding of water.

2. Adequate drains should be installed to prevent ponding of water on berms or behind spoil banks, levees, and dikes.

3. Diversion channels and drainage ditches should be designed, constructed, and maintained so that they will concentrate low flows and reduce silt deposition and subsequent ponding, thereby insuring free flows at all times.

4. Underdrains, culverts, inlets, etc., should be placed on grade to prevent ponding.

5. Sections of natural drainageways that are cut off or bypassed by new channels should be filled or provided with adequate drains.

B. Detention Basins

1. All borrow pits and other potential ponding areas associated with construction of the dam, relocation of highways or roads, etc., which are located above maximum pool level should be made self-draining.

2. The normal fluctuation zone of the permanent pool should be completely cleared except for isolated trees and sparse vegetation along abrupt shorelines which will be exposed to wave action.

3. Borrow pits, depressions, and marshes which will be flooded at maximum pool level and which would retain water at lower pool levels should be provided with drains to insure complete drainage or fluctuation of water within them.

C. Water Spreading Areas

1. Borrow areas resulting from construction of the spreading areas should be made self-draining.

2. The shoreline margins of the spreading areas should be steep sided to discourage the growth of vegetation.

3. The areas over which water will be spread should be properly graded to prevent ponding.

4. If water is ponded on the areas during the mosquito-producing season, they should be designed and constructed so that a minimum water depth of two feet can be maintained in order to minimize conditions favorable for mosquito production.

5. Dense vegetation and flotage should be removed periodically from areas in which water is ponded for periods of a week or more during the mosquito-producing season.

D. Recreational Areas

1. Proper storage, collection, and disposal of refuse should be practiced in order to prevent and control flies, wasps, other noxious insects, rats, wild rodents, and other small mammals.

2. All buildings should be rodentproofed at recreational areas where rodents are prevalent which may create public health hazards.

3. Debris, rubbish, and other materials which may serve as harborage for rodents and other small mammals should be removed periodically.

4. Brush and weeds along paths, trails, roadways, and other areas of frequent use by visitors should be removed in order to reduce the likelihood of tick infestation.

APPENDIX A

Biology of Mosquitoes

This discussion is intended to provide only basic information concerning some of the more pertinent biological characteristics of mosquitoes commonly associated with water resource developments. These mosquitoes represent four important genera or groups: Anopheles, Culex, Aedes, and Psorophora. All mosquito species have four distinct stages in their life cycle: the egg, the larva ("wiggler"), the pupa ("tumbler"), and the adult. A characteristic common to all mosquitoes is that they live in water continuously from the time the eggs hatch until the adults emerge. The aquatic stages generally occur in shallow water with an abundance of vegetation and flotage, and where they are protected from wave action. They do not occur in the deep open waters of lakes, ponds, or streams.

On the basis of egg-laying habits, mosquitoes may be divided into temporary-water and permanent-water species. The Aedes and Psorophora are temporary water breeders which deposit their eggs on the moist soil of areas where surface water has receded. Hatching of the eggs is stimulated by subsequent floodings. The eggs may remain dormant for long periods, sometimes for several years if conditions are unfavorable for hatching. Normally, the eggs hatch more or less simultaneously soon after they are flooded. In contrast, the Anopheles and Culex usually lay their eggs on the surface of permanent and semipermanent bodies of water. The eggs usually hatch within a few days after oviposition. For both the temporary-water and permanent-water mosquitoes, time between hatching of eggs and emergence of adults varies with species and environmental conditions, especially water temperature. Development of the aquatic stages may be completed in as little as four days in hot weather while several weeks may be required in cool weather. Aedes and Psorophora mosquitoes generally develop more rapidly than the Anopheles and Culex.

Adult mosquitoes mate soon after emergence and the females begin seeking blood meals, which most species require before laying eggs. The biting habits of adult mosquitoes vary with species. Anopheles and Culex mosquitoes feed mainly at night while Aedes and Psorophora species feed both at night and in the daytime. Most species exhibit a peak of biting activity during a one- or two-hour period immediately after sundown. The Aedes and Psorophora species are aggressive and vicious biters of both man and livestock. Culex tarsalis, a vector of encephalitis, feeds readily on a wide range of hosts including man, wild and domestic birds, and livestock.

The flight range of mosquitoes varies widely with species and environmental conditions. The direction and distance of travel are greatly influenced by availability of food, shelter, and wind conditions. Availability of food is probably the most important factor influencing the movement of mosquitoes in many areas. If an adequate food supply is close to

the production sites, adult mosquitoes probably will not travel far from their sources. On the other hand, mosquitoes may travel several miles when adequate food supplies are not available nearer their larval habitats. The normal flight range of the Anopheles and Culex mosquitoes is usually considered to be about one mile, although recent studies have shown that certain species such as C. tarsalis may travel several miles under certain environmental conditions. Most Aedes and Psorophora species are strong fliers and are known to range several miles from their larval habitats.

APPENDIX B

Public Health and Socio-Economic Importance of Vector Problems Associated with Water Resource Developments

Several groups of arthropods and rodents associated with the development and utilization of water resources may create serious public health and socio-economic problems. These include species that are vectors of disease organisms or serve as reservoirs of these organisms or which otherwise interfere with man's health and welfare.

Mosquitoes

Approximately a dozen species of mosquitoes of public health and socio-economic importance may be produced in habitats associated with irrigation, impoundments, and other water resource developments. Encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the United States. Mosquitoes obtain the encephalitis viruses from wild vertebrates and then transmit them to horses and humans. There are no effective chemotherapeutic measures for preventing or treating human cases; and some individuals, particularly children, who recover from encephalitis often suffer permanent mental disability. Three principal types of mosquito-borne encephalitis occur in the United States. Eastern encephalitis (EE) occurs mainly in the Atlantic and Gulf Coast States from New Hampshire to Texas, but sometimes extends as far inland as Wisconsin. St. Louis encephalitis (SLE) occurs chiefly west of the Mississippi River and in several of the Central States. The third type, western encephalitis (WE), is confined primarily to the states west of the Mississippi River.

Culiseta melanura and several species of Aedes mosquitoes are believed to be involved in the transmission of EE. The principal vector of both WE and SLE in the Far West is Culex tarsalis, a mosquito which is widely distributed west of the Mississippi River. In the Central States, Culex pipiens and Culex quinquefasciatus are believed to be important in the transmission of SLE. Aedes and other mosquitoes may also be involved as secondary vectors of encephalitis. Both western and St. Louis encephalitis are endemic in many western areas, and outbreaks of WE among horses and of WE and SLE among humans have been rather widespread. In recent years, outbreaks of encephalitis have occurred in irrigated areas in the Texas High Plains (1956), in the Intermountain States (1957), in the Lower Rio Grande Valley (1957), in Utah and New Mexico (1958), and in Wyoming (1960).

The occurrence of malaria outbreaks as a result of improperly prepared reservoirs in the Southeastern States is well documented. Malaria has also been associated with irrigation in several states including California, New Mexico, Texas, and in the rice-growing areas of the Mississippi Delta. This disease has been almost eradicated from the United States; and at present, there is no significant malaria trans-

mission anywhere in the Nation. The malaria vectors (Anopheles quadrimaculatus in the East and Anopheles freeborni in the West) are still prevalent in some areas where favorable habitats are present. These mosquitoes constitute a potential hazard for the establishment of new foci of malaria transmission, particularly in situations where the disease may be reintroduced from foreign countries. This was well illustrated at Lake Vera in California during the summer of 1952, where 35 cases of malaria occurred among Camp Fire Girls. The source of their infections was traced to a soldier who had an attack of malaria while camping at the lake.

Several vicious-biting species including Aedes vexans, Aedes dorsalis, and Aedes nigromaculis may be produced in habitats associated with irrigation and other water resource projects. These mosquitoes often create public health problems aside from the transmission of specific diseases. Such health hazards are illustrated by the results of surveys made by the U. S. Public Health Service in irrigated areas in northern Montana. In three-fourths of the families surveyed, mosquitoes severely annoyed both adults and children and interfered with their normal outdoor activities during the summer months. Mosquito bites caused some degree of injurious reaction in 8 out of 10 people interviewed; and in one section, 40% of the individuals examined by the physician showed evidence of secondary infection of mosquito bites. Some individuals, particularly children, frequently required medical attention and sometimes even hospitalization for treatment of secondary infections and occasional allergic reactions caused by mosquito bites.

In addition to their public health importance, mosquitoes often create other serious problems in both rural and urban areas. Their vicious biting reduces the efficiency of farm workers and sometimes hinders the harvesting of crops. Dense populations of attacking mosquitoes have been reported to kill livestock. The constant attacks of even moderate populations of these insects may reduce the vitality of farm animals and prevent proper feeding, thereby causing reduced weight gains and lower milk and egg production. Mosquitoes are vectors of encephalitis, anaplasmosis, fowl pox, and several other important diseases of animals. These diseases kill large numbers of farm animals each year. Together, mosquito annoyance and mosquito-transmitted diseases undoubtedly result in losses of millions of dollars to farmers every year.

Large numbers of biting mosquitoes also cause serious economic losses by reducing the efficiency of industrial workers, lessening the value of real estate, restricting outdoor recreational activities, and reducing attendance at outdoor business establishments such as drivein theatres and eating places.

The economic magnitude of the irrigation-mosquito problem alone is illustrated by expenditures for abatement of these insects. For example, in California over $5,000,000 is spent annually to control encephalitis and other irrigation mosquitoes and it has been estimated that at least

twice this amount would be required to provide adequate control throughout the State. Approximately $200,000 is spent each year for mosquito abatement in a few irrigated areas in Utah. Many urban communities in other western irrigated areas spend large sums of money each season for chemical control to provide partial protection from mosquitoes. Individual families also spend sizable amounts of money each summer for household sprays, mosquito repellents, livestock sprays, and medicine for treatment of mosquito bites. The total cost of controlling irrigation mosquitoes, together with the other serious economic losses they cause, runs into many millions of dollars each year. Thus, mosquitoes are a major economic liability in many irrigated areas.

Other Aquatic Insects

Several other groups of aquatic insects may be produced in sufficient numbers in habitats associated with water resource projects to create public health and economic problems. Deer flies and horse flies (Tabanidae) are produced along the margins of impoundments and in seeps and marshes in irrigated areas. These insects are vicious biters of both man and livestock and are sometimes involved in the transmission of diseases such as tularemia and anthrax. Some species of small gnats of the family Heleidae are also vicious biters and often produce severe reactions and vesicular lesions. These gnats are produced in damp areas of many irrigated valleys as well as salt marshes and other wetland areas. In certain areas, black flies (Simuliidae) plague both man and livestock with their irritating and painful bites. They are normally produced in streams but sometimes occur in large numbers in irrigation conveyance systems. The small nonbiting midges (Tendipedidae) and the phantom midges (Chaoborinae) are another group of pestiferous insects which may be produced in impounded water. These insects are attracted to lights in tremendous numbers and cause severe human annoyance. An example is the Clear Lake gnat, Chaoborus astictopus, which creates serious problems at the resort areas in Lake County, California.

Terrestrial Arthropods and Rodents

Each summer, many millions of people visit picnic sites, campgrounds, cabins, and other water-related recreational facilities along the shores of reservoirs. In addition to mosquitoes and other insects of aquatic origin, these people are often exposed to terrestrial arthropods such as ticks, mites, fleas, and flies and rodents including ground squirrels, rats, mice, and chipmunks. The public health importance of these arthropods and rodents involves a number of human diseases including Rocky Mountain spotted fever, Colorado tick fever, tularemia, relapsing fever, tick paralysis, typhus, plague, bacillary dysentery, and typhoid. The bites of certain arthropods also cause considerable irritation, discomfort, and annoyance.

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 17, California

SPLGP-F

8 January 1964

Regional Program Director
Water Supply and Pollution Control
Public Health Service, DHEW
447 Federal Office Building
San Francisco, California 94102

Dear Sir:

Your letter of 17 December 1963 containing your report on the Public Health aspects of our proposed "Interim Report on Survey for Flood Control, Phoenix, Arizona, and Vicinity (including New River)," is appreciated.

The recommendations contained in your report will be considered in later general design studies or during construction of the proposed flood-control improvements.

Sincerely yours,

A. R. MARSHALL
Lt. Col., Corps of Engineers
Acting District Engineer

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Arizona State Office
6029 Federal Building
Phoenix, Arizona 85025

November 20, 1963

District Engineer
U.S. Army Engineer District, Los Angeles
P.O. Box 17277, Foy Station
Los Angeles, California 90017

Reference: SPLGP-F

Dear Sir:

This responds to your letter of November 18, 1963 requesting us to submit our comments on the Interim Report on Survey for Flood Control, Phoenix, Arizona and Vicinity, (including New River).

The report recommends that the United States adopt a project for the control of floods along Cave and Skunk Creeks and along the New and Agua Fria Rivers within the metropolitan area of Phoenix, Arizona. The recommended plan provides for the construction of four dams, one each on Cave Creek, Skunk Creek, the New River and Dreamy Draw; the Union Hills and Arizona Canal diversion channels and the Cave Creek, Dreamy Draw, Skunk Creek, the New River, and the Agua Fria River channel improvements.

A review of the report reveals that the proposed project, in addition to providing much needed flood protection to the metropolitan area of Phoenix, Arizona, would also provide protection to high-producing, high-value irrigated croplands. The proposed project if installed would be of tremendous value to farmers of the flood plain.

The proposed program does not adversely affect the program or planned program of the Soil Conservation Service. It is a part of the co-ordinated comprehensive flood control program of the County of Maricopa, Arizona in which the Soil Conservation Service is participating.

Sincerely yours,

Robt. V. Boyle

Robt. V. Boyle
State Conservationist

cc: E.J. Core
L.A. Hill
W.E. Rhinehart

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
AREA HYDROLOGIC ENGINEER
650 Capitol Mall, Room 8102
Sacramento, California 95814

December 3, 1963

District Engineer
U.S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Subject: Proposed Interim Report for Flood Control - Phoenix Arizona, and vicinity

Dear Sir:

Mr. Louis R. Jurwitz, Meteorologist in Charge, of the Weather Bureau Airport Station in Phoenix, Arizona, was asked to review the above mentioned report. The following are his comments:

"I have carefully reviewed sections of reference report for climatology and have no corrections or additions to suggest. In my opinion, the report is well presented. Proposed works, if accomplished, should provide needed protection to life and property in the Phoenix Metropolitan area.

Due to the erratic nature of flash-flood producing storms and the limited time between rainfall and runoffs, it is impractical, at present to provide adequate warning service of possible flooding. Recommended projects should provide needed protection from serious flooding in the Metropolitan Phoenix area, and appear feasible as evidenced by the ratio of average benefits to annual charges of 2.9 to 1."

Sincerely yours,

J. van de Erve
Western Area Engineer

ARIZONA GAME & FISH DEPARTMENT

State Office Building Phoenix 7, Arizona 271-4295

December 9, 1963

District Engineer
U.S. Army Engineer, L.A.
P.O. Box 17277, Foy Station
Los Angeles 17, California

Dear Sir:

We appreciate the opportunity to comment on your Interim Report in relation to development of Phase B, the proposed Phoenix and Vicinity (Including New River) Flood Control Project.

The primary objectives of Phase B will be the construction of four flood water detention basins with a combined capacity of 88,150 acre-feet, 22.75 miles of diversion channels and 29.1 miles of channelization along existing river beds.

No storage for water conservation is presently provided for in any of the flood water detention structures. Plans call for ungated spillway outlets. We feel that some provision should be made in the initial planning to allow for future consideration and possible expansion in the event a conservation pool is feasible. The various flood control projects so designed and authorized do not provide adequate storage to consider fishing. We note with interest that recreation, however, has been planned into these developments under the multiple-purpose features. Without storage, recreation would be limited.

Fishing is non-existent now, and with the project, as it is currently written, no fish habitat will be created. The possibility of storage in the Cave Buttes and Lower New River should not be overlooked. The latter may necessarily be disqualified because of the porous land formation in that area.

However, until there are definite findings from core drilling and other engineering investigations to eliminate Lower New River, this area still remains of vital interest to us. This was emphasized in Mr. Arrington's letter to you of June 13, 1963, in which it was pointed out that a minimum pool at elevation 1430 would create a 612 surface acre lake with 8,000 acre-feet capacity.

According to our findings, the Cave Buttes site has 193 square miles drainage. The area above the old dam has 162 square miles of drainage. Although the additional 30 square miles of drainage at the lower Cave Buttes site is not appreciable, it does collect water from an area to the east. It seems possible a greater depth will occur at the lower site with the same amount of water.

With the possibility of water from other sources, some exchange program might be developed whereby a conservation level behind the detention dams could be maintained. During flood periods and runoff, water can then be returned by release to the canals. This was discussed several times with representatives of various agencies and the idea did not appear to be too far out of line.

Potential wildlife habitat losses within the flood water retention area cannot be disregarded as insignificant. In the river bottoms, a great concern is felt for the riparian vegetation along the water courses. We are fully aware of the need for developing more effective water conservation measures. At the same time, we are providing maximum populations of huntable game for the ever increasing hunter population and demand.

Many species of game birds and animals inhabit these areas, especially the upland game species. In the sparsely vegetated desert regions, the significant growth along washes and stream courses provide the only protective cover for these animals. Elimination of any vegetation will have a definite effect on the existing wildlife and the potential wildlife production in these areas.

Again, we wish to express our appreciation for the opportunity to offer comments and suggestions on this phase of the project.

Sincerely,

R. J. Smith, Director

/s/

By: John P. Russo
River Basin Supervisor

JPR:ms

cc: Field Supervisor
U.S. Fish & Wildlife Ser.
Branch of River Basin Studies
Phoenix, Arizona

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 17, California

SPLGP-F

30 December 1963

Mr. R. J. Smith
Director
Arizona Game and Fish
Department
State Office Building
Phoenix 7, Arizona

Dear Mr. Smith:

Reference is made to your letter of comment of 9 December 1963, regarding our proposed interim report for flood control, Phoenix, Arizona, and vicinity (including New River).

You point out that some provision should be made in the initial planning to allow for future consideration and possible expansion of fish and wildlife in the event a conservation pool is feasible. You indicate that the possibility of water-conservation storage in the Cave Buttes and New River detention basins should not be overlooked. You also indicate concern for the elimination of vegetative growth and subsequent potential wildlife-habitat losses within the detention basin areas and along the water courses.

With respect to the latter comment, serious consideration will be given, in developing detailed plans, to providing a minimum disturbance of trees and shrubs.

This office gave consideration to development of fish and wildlife and recreation facilities at the proposed reservoir sites. We found that because of the low average annual yield, the high evaporation, and the large infiltration losses, fish and wildlife or recreation facilities that could be developed would be minor and probably could not be justified.

In addition, the Granite Reef aqueduct of the Central Arizona project, proposed by the Bureau of Reclamation, crosses New River, Skunk Creek, and Cave Creek in the vicinity of the proposed detention basins. A definite location for this aqueduct has not been determined and all features of the Bureau project have not been firmed. With the importation of Colorado River water to the area, the proposed detention basins probably could be adapted for multiple-purpose use with

mutual advantages for the Central Arizona project aqueduct facilities, the future municipal water supply treatment and distribution facilities of the city of Phoenix supplied by the Central Arizona project, recreation plans of the Maricopa County Parks and Recreation Department, and fish and wildlife facilities to be developed jointly with your office and the U.S. Bureau of Sport Fisheries and Wildlife.

This office has not made further studies of fish and wildlife and recreation development under present water supply conditions because of: (1) the apparent minor aspect of a fish and wildlife and recreation program under conditions whereby water supplies would be limited to the natural flows of the streams involved; (2) the probability that importation of water from the Colorado River under the Central Arizona project would enhance the opportunity to develop fish and wildlife and recreation resources; and (3) the inability to develop detailed plans utilizing Colorado River water until firm plans are developed by the Bureau of Reclamation. Addition of fish and wildlife and recreation facilities would not appreciably change the overall conclusions of the report. However, you can be assured that if the Phoenix project is authorized for construction, detailed consideration will be given to fish and wildlife and recreation aspects in the definite project studies, to assure that maximum development at the proposed detention basins is achieved.

Sincerely yours,

/s/ A. R. MARSHALL
Lt. Col., Corps of Engineers
Deputy District Engineer

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K. WILLIAM HOLBROOK
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JUSTIN HERMAN
STATE HIGHWAY DIRECTOR

WM. N. PRICE
STATE ENGINEER

ARIZONA HIGHWAY DEPARTMENT

Phoenix, Arizona 85007

January 9, 1964

Colonel Earl G. Peacock
District Engineer
U. S. Army Engineer District, Los Angeles
P. O. Box 17277, Foy Station
Los Angeles 17, California

Subject: Your File SPLGP-F
Flood Control - Phoenix, Arizona and Vicinity

Dear Colonel Peacock:

In accordance with your letter of November 18, I have reviewed the Interim Report for Flood Control, Phoenix, Arizona and Vicinity (including New River).

The following State agencies which will be involved with the proposed plan have expressed their views as noted below:

> The Arizona Game and Fish Department are concerned over the affect of the program on wildlife and are also interested in the development of recreational areas as expressed in their letter of December 9 to you.
>
> The State Land Department will cooperate with the Flood Control District in securing rights-of-way across State lands.
>
> The Arizona Highway Department will cooperate with the Corps in their preparation of plans for the proposed crossings of State highways.

I also strongly recommend that all possible consideration be given to any modifications which would permit development of multiple purpose features.

The comprehensive plan of flood control has been shown to be economically feasible and conforms to the interests and needs of the Phoenix area. I therefore concur with the recommendations as expressed in the Interim Report.

Very truly yours,

/s/ Martin Toney

MARTIN TONEY
Engineer of Bridges & Dams

MT/ff

cc: Governor Fannin

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
751 South Figueroa Street
Los Angeles 17, California

SPLGP-F

17 January 1964

Mr. Martin Toney
Engineer of Bridges and Dams
Arizona Highway Department
1739 West Jackson Street
Phoenix, Arizona 85007

Dear Mr. Toney:

Reference is made to your letter of comment dated 9 January 1964, regarding our proposed interim report for flood control, Phoenix, Arizona, and vicinity (including New River).

You point out that the Arizona Game and Fish Department is concerned over the effect of the proposed flood-control program on wildlife and is also interested in the development of recreation areas. In our reply to the Director of the Arizona Game and Fish Department, we pointed out that this office gave consideration to development of fish and wildlife and recreation facilities at the proposed reservoir sites. We found that under present conditions, wherein water supplies were limited to the natural flows of the streams involved, fish and wildlife or recreation facilities that could be developed would be minor and probably could not be justified because of the low average annual yield of the streams involved, the high evaporation, and large infiltration losses that would occur in the reservoir areas.

However, we noted that the Granite Reef aqueduct of the Central Arizona project, proposed by the Bureau of Reclamation, crosses New River, Skunk Creek, and Cave Creek in the vicinity of the proposed detention basins. A definite location for this aqueduct has not been determined and all features of the Bureau project have not been firmed. With the importation of Colorado River water to the area, the proposed detention basins probably could be adapted for multiple-purpose use with mutual advantages for the Central Arizona project aqueduct facilities; the future municipal water supply treatment and distribution facilities of the city of Phoenix, supplied by the Central Arizona project; recreation plans of the Maricopa County Parks and Recreation Department; and fish and wildlife facilities, to be developed jointly with the Arizona Game and Fish Department and the U.S. Bureau of Sport Fisheries and Wildlife.

SPLGP-F 17 January 1964
Mr. Martin Toney

As indicated to the Director of the Arizona Game and Fish Department, this office has not made further studies of fish and wildlife and recreation development under present water supply conditions because of: (a) the apparent minor aspect of a fish and wildlife and recreation program under present conditions; (b) the probability that importation of water from the Colorado River under the Central Arizona project would enhance the opportunity to develop fish and wildlife and recreation resources; and (c) the inability to develop detailed plans utilizing Colorado River water until firm plans are developed by the Bureau of Reclamation. Addition of fish and wildlife and recreation facilities would not appreciably change the overall conclusions of the report. However, we can assure you that, if the Phoenix project is authorized for construction, detailed consideration will be given to fish and wildlife and recreation aspects in the definite project studies, to assure that maximum development at the proposed detention basins is achieved.

The expressions of cooperation of the State Land Department in securing rights-of-way for local interests and of the Arizona Highway Department in preparation of plans for proposed crossings of State highways are appreciated.

Sincerely yours,

/s/ SHELTON B. BILES
Major, Corps of Engineers
Assistant District Engineer

APPENDIX 6 - RESOLUTION BY LOCAL INTERESTS

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

RESOLUTION OF MARICOPA COUNTY FLOOD CONTROL DISTRICT

WHEREAS, Act of Congress, Public Law 761, Seventy-fifth Congress, approved June 28, 1938, authorized a preliminary examination and survey for flood control on the Gila River and tributaries, Arizona and New Mexico;

WHEREAS, a flood-control project for Phoenix, Arizona and vicinity is being considered in an interim report under preparation by the District Engineer, U.S. Army Engineer District at Los Angeles, California;

WHEREAS, protection against flood damage would be provided to urban and agricultural lands in the Phoenix metropolitan area by flood control improvements under consideration for construction by the United States;

WHEREAS, Section 3 of Public Law 738, Seventy-fourth Congress, provides that no money appropriated shall be expended on the construction of any project until States, political subdivision thereof, or any other responsible local agencies have given assurances satisfactory to the Secretary of the Army that they will assume certain enumerated obligations;

WHEREAS, Title 45, Chapter 10, Section 45-2360 of the Arizona State Water Code authorizes the Board of Directors of any Flood Control District to co-operate with the United States in the construction of flood-control works.

WHEREAS, the Board of Directors of The Flood Control District of Maricopa County has considered the need for flood control in the Phoenix metropolitan area, and has agreed that it go on record supporting the flood-control program under consideration by the United States Army Engineers.

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of The Flood Control District of Maricopa County, Arizona, that, if a flood-control project consisting of detention basins on Dreamy Draw, Cave Creek, Skunk Creek, and New River; a diversion channel generally parallel to and north of Bell Road; a diversion channel parallel to and just upstream from the Arizona Canal from 12th Street to Skunk Creek; and improved channel along Cave Creek, Dreamy Draw, Skunk Creek, New River and Agua Fria River be found economically feasible and be authorized by act of Congress, the

Flood Control District of Maricopa County will participate to the best of its ability by assuming the following obligations:

a. Acquire and provide, without cost to the United States, all lands, easements, and rights-of-way necessary for the construction of the project, at a cost presently estimated at $7,320,000.

b. Perform, without cost to the United States, all necessary relocations of highways and roads (including bridges), utilities, and all necessary street modifications required in connection with the project, at a cost presently estimated at $3,000,000.

c. Hold and save the United States or any instrumentality, department or agency thereof, free from any damages arising from construction, maintenance, and operation of the work.

d. Maintain and operate, upon completion, all works in accordance with regulations to be prescribed by the Secretary of the Army.

e. Establish and enforce flood-channel limits and regulations, satisfactory to the Secretary of the Army, for the preservation of the flood-carrying capacities of the proposed improvements.

BE IT FURTHER RESOLVED that this resolution be entered in the minutes of the Board of Directors of the Flood Control District of Maricopa County and in the minutes of the Board of Supervisors of the County of Maricopa and that the Clerk of said County be, and he is hereby directed to forward a certified copy of this resolution to the District Engineer, U.S. Army Engineer District, Los Angeles, Corps of Engineers, P.O. Box 17277, Foy Station, Los Angeles 17, California.

PASSED AND APPROVED this 4th day of November, 1963.

/s/ B. H. Burns
Chairman of the Board of Directors
of the Flood Control District of
Maricopa County

ATTEST:

/s/Rhea Averill
Clerk of the Board

PHOENIX, ARIZ., AND VICINITY (INCLUDING NEW RIVER)
GILA RIVER BASIN, ARIZ. AND N. MEX.

Information called for by
Senate Resolution 148, 85th Congress
Adopted January 28, 1958

1. Problems considered.--A serious flood problem exists along Dreamy Draw, Cave Creek, and Skunk Creek and along the New and the Agua Fria Rivers, which are the major streams under detailed consideration in this report. Until recently, floods along Dreamy Draw and Cave Creek rarely caused large damages, mainly because of the predominantly agricultural development in the overflow area. However, with the population explosion in the Phoenix metropolitan area - particularly since 1950, the flood-damage potential has increased tremendously. The flood channels of Dreamy Draw and Cave Creek disappear at the Arizona Canal and not even a trace of a stream is evident downstream. The area downstream from the canal is now intensively developed with urban-type property - predominantly residential, commercial, and industrial improvements. Floods along Skunk Creek, the New River, and the Agua Fria River cause damage to mainly agricultural-type property, except at the communities of Peoria and Avondale.

2. Damage to property in the overflow areas is caused principally by inundation and debris deposition. The floodflows result primarily from local thunderstorm rainfall of high intensity and short duration. Along the New River and the Agua Fria River, severe bank and surface erosion occurs. Inundation damage will also cause severe disruption of activities, both inside and outside the flooded area. Because of the continued growth in the overflow area, damages will be greater under future conditions than under present conditions.

3. Water-conservation problems or other problems related to flood problems are not of sufficient magnitude to warrant detailed investigation in connection with this flood-control survey.

4. Recommended improvement.--The recommended plan of flood-control improvement provides for (a) four dams and detention basins - one each on Cave Creek, Skunk Creek, the New River, and Dreamy Draw; (b) the Union Hills and the Arizona Canal diversion channels; and (c) the Cave Creek, the Dreamy Draw, the Skunk Creek, the New River, and the Agua Fria River channel improvements. The plan provides for controlling as much of the floodflow as possible in the drainage area involved; for diverting residual flows in Cave Creek and several small washes to Skunk Creek; and for improving Skunk Creek, the New River, and the Agua Fria River to carry these residual flows to an adequate point of disposal in the Gila River.

5. Pertinent information on each of the units of improvement under the recommended plan is given in the following subparagraphs.

(a) Cave Buttes detention basin.--The Cave Buttes detention basin would be constructed about 2 miles downstream from the existing Cave Creek Dam. The main embankment would be a compacted-earthfill structure with a maximum height of about 120 feet above streambed. The crest of the dam would be about 2,100 feet long. Two earthfill dikes, about 12,100 feet in total length, would be required. The detention basin, which would have a capacity of 28,800 acre-feet at spillway crest, would be designed to reduce a standard project flood with a peak inflow of 79,000 cubic feet per second to an outflow of 5,400 cubic feet per second.

(b) Cave Creek channel.--The Cave Creek channel would be a trapezoidal concrete-lined channel about 3.6 miles long, extending from the outlet of the proposed Cave Buttes Dam to the proposed Union Hills diversion channel. The channel, which would have a bottom width of 10 feet and a depth of about 10 feet, would accommodate a discharge of 6,000 cubic feet per second. The entire channel would be excavated below natural ground. No bridges or utility relocations are expected.

(c) Union Hills diversion channel.--The Union Hills diversion channel would be a trapezoidal concrete-lined channel about 9-3/4 miles long, extending from the divide between the Cave Creek and Indian Bend Wash drainage areas, near 40th Street, to Skunk Creek. The channel would have bottom widths ranging from 15 to 60 feet and depths ranging from 10 to 18 feet. The design discharge of the channel would range from 2,000 cubic feet per second at the upstream end to 13,400 cubic feet per second at the downstream outlet into Skunk Creek. The channel would be excavated entirely below natural ground. Seven bridges - one each at 32nd Street, Union Hills Drive, Cave Creek Road, 7th Street, 19th Avenue, Black Canyon Highway, and 35th Avenue - would be required. About 1,800 feet of Union Hills Drive would be relocated.

(d) Dreamy Draw detention basin.--The Dreamy Draw detention basin would be constructed in Dreamy Draw just south of Shea Boulevard and 1 mile east of 16th Street. The main embankment would be a compacted-earthfill structure with a maximum height of about 50 feet above streambed. The crest of the dam would have a length of 480 feet. Two earthfill dikes, with a total length of 1,800 feet, would be required. The detention basin, which would have a capacity of 450 acre-feet at the spillway crest, is designed to reduce a standard project flood with a peak inflow of 2,180 cubic feet per second to an outflow of 100 cubic feet per second.

(e) Dreamy Draw channel.--The Dreamy Draw channel would be a rectangular concrete channel with a 10-foot base width, extending from the Dreamy Draw detention-basin outlet to the Arizona Canal

diversion channel, a length of about 3-1/2 miles. The design capacity would range from 100 cubic feet per second at the upstream end to 1,500 cubic feet per second at the downstream end. The channel, which would be excavated entirely below the natural ground, would have depths ranging from 7 to 9 feet. Bridges at Shea Boulevard, 16th Street, Winter Drive, 14th Street, Belmont Avenue, and 12th Street would be required.

(f) Arizona Canal diversion channel.--The Arizona Canal diversion channel, which would be just upstream from the Arizona Canal and nearly parallel to that canal, would extend from Dreamy Draw to Skunk Creek. The channel would comprise a 2-mile-long rectangular concrete section at the upstream end and a 10-mile-long trapezoidal earth section at the downstream end. The rectangular channel would have bottom widths ranging from 10 to 50 feet and depths ranging from 8 to 18 feet. The trapezoidal earth section would have bottom widths ranging from 20 to 220 feet and depths ranging from 8 to 20 feet. The design capacity of the channel would range from 1,500 to 18,500 cubic feet per second. Bridges would be required at 7th Street, Central Avenue, 7th Avenue, 19th Avenue, Black Canyon Highway, 43rd Avenue, 51st Avenue, 59th Avenue, and Northern Avenue.

(g) Adobe detention basin.--The Adobe detention basin would be constructed on an unnamed tributary of Skunk Creek, about 7 miles north of Bell Road and about 1 mile west of the Black Canyon Highway. The embankment would be a compacted-earthfill structure with a maximum height of about 76 feet above streambed. The crest of the dam would have a length of 3,850 feet. The detention basin, which would have a capacity of 19,400 acre-feet, would reduce a standard project flood with a peak inflow of 50,000 cubic feet per second to an outflow of 2,000 cubic feet per second. A diversion channel about 2-1/2 miles long would be excavated in earth to divert a standard project flood on Skunk Creek to the Adobe detention-basin area. Construction of the diversion channel would require construction of a bridge for the Black Canyon Highway.

(h) Skunk Creek channel.--The Skunk Creek channel would be a concrete-lined trapezoidal channel constructed along Skunk Creek from a point just upstream from the outlet of the Union Hills diversion channel downstream to a confluence with the New River, a distance of about 6-1/2 miles. The channel would have a design capacity ranging from 24,400 to 41,400 cubic feet per second, base widths ranging from 15 to 40 feet, and depths ranging from 10 to 23 feet. Bridges at 59th Avenue, Bell Road, and 83rd Avenue would be required; and about 2,000 feet of Union Hills Drive would be relocated.

(i) New River detention basin.--The New River detention basin would be constructed on the New River about 8 miles upstream from

the mouth of Skunk Creek. The main embankment would be a compacted-earthfill structure with a maximum height of about 80 feet above streambed. The crest of the embankment would be 2,700 feet long. An earthfill dike about 4,900 feet long would be required along the west edge of the detention-basin area. The detention basin, which would have a capacity of 39,500 acre-feet, would reduce a standard project flood with a peak inflow of 60,000 cubic feet per second to an outflow of 1,000 cubic feet per second.

(j) New River channel improvement.--The improved channel for the New River would extend from the mouth of Skunk Creek downstream to the confluence with the Agua Fria River, a distance of about 8 miles. The channel, which would be excavated in earth, would have revetted side slopes. The channel would be a trapezoidal section with bottom widths ranging from 400 to 800 feet and depths ranging from 8-1/2 to 11 feet. The design capacity of the channel would range from 53,400 cubic feet per second at the U.S. Highway No. 60 crossing of the channel to 58,000 cubic feet per second at the mouth of the New River. The Sante Fe railroad, the U.S. Highway No. 60, and the Glendale Avenue bridges would require modification. Dip crossings would be required at Thunderbird Road and at Peoria, Northern, and Olive Avenues.

(k) Agua Fria channel improvement.--An excavated earth channel would be constructed in the Agua Fria River for a distance of 7-1/2 miles from the mouth of the New River to a point about 2 miles downstream (south) of the bridge for U.S. Highway No. 80. The channel would be a trapezoidal section with base widths ranging from 800 to 1,500 feet and depths ranging from 8-1/2 to 10 feet. The design capacity of the channel would range from 70,000 to 74,000 cubic feet per second. About 1/2 mile of El Mirage Road would be relocated. Dip crossings would be provided for Van Buren Street and for Indian School, Thomas, and McDowell Roads.

6. Each of the detention basins would be designed to control a standard project flood from the drainage area upstream from the dam. Each of the diversion channels and the other channel improvements would be designed to control the runoff estimated to occur on an average of about once in 100 years. Floods of these magnitudes, although only about 46 percent of the standard project flood, are larger than any known flood of record in the metropolitan area. The capacities of the recommended channels would be considerably more than the nondamaging capacities of the existing washes. Improvements under the recommended plan would prevent about 89 percent of the total average annual damages in the overflow areas along Dreamy Draw, Cave Creek, and Skunk Creek; along the New and the Agua Fria Rivers; and along the small washes between Cave Creek and the Agua Fria River. Most residual damages would result from flows originating downstream from the proposed works. The economic life of each project unit is considered to be 100 years.

7. Project costs.--The estimated first costs for the recommended project, based on October 1963 prices, are given in the following table:

Estimated first costs of recommended project - Phoenix, Ariz., and vicinity (including New River)

Item	Estimated first costs
Federal (construction of channels and detention basins)	$59,680,000
Non-Federal (rights-of-way and relocations)	11,120,000
Total	70,800,000

8. The average annual cost (all non-Federal) for maintenance and operation is estimated at $223,000 Preauthorization costs of $275,000 already expended are not included in the preceding estimates.

9. Benefit-cost ratio.--Average annual costs and benefits and benefit-cost ratios for the recommended project, developed on the basis of an economic life of 50 years and an economic life of 100 years, are given in the following table. An interest rate of 3 percent was applied, and October 1963 prices were used.

Pertinent information on average annual costs and benefits and benefit-cost ratios for recommended project - Phoenix, Ariz., and vicinity (including New River)

Item	Life of project	
	100 years	50 years
Average annual costs:		
Interest and amortization (Federal)	$1,927,000	$2,367,000
Interest and amortization (non-Federal)	581,000	665,000
Maintenance and operation (non-Federal)	228,000	228,000
Total	2,736,000	3,260,000
(Say)	2,740,000	3,260,000

Pertinent information on average annual costs and benefits and benefit-cost ratios for recommended project - Phoenix, Ariz., and vicinity (including New River)--Continued

Item	Life of project	
	100 years	50 years
Average annual benefits:		
Prevention of flood damages	$7,750,000	$5,830,000
Increased utilization of land	460,000	420,000
Total	8,210,000	6,250,000
Ratio of benefits to costs	3.0 to 1	1.9 to 1

10. Intangible project effects.--Many benefits not susceptible of monetary evaluation would accrue from the operation of the improvements considered in this report. Such benefits would include reduction of the danger of loss of life from floods. Loss of life has occurred in the Phoenix area in previous floods; with the rapidly increasing development in the overflow area, the danger of loss of life is increasing. Other intangible benefits would result from (a) prevention of such interruption of services from the Arizona Canal as would occur when the canal is emptied to perform flood-control diversion during rainstorms or is breeched by floodflows; (b) reduction of epidemics caused by flood damages to sewer and water systems; (c) prevention of interruptions to traffic, business transactions, public utilities, home life, and school and other normal community activities; and (d) preservation of community morale by reducing the fear of floods in the overflow areas.

11. Current and future needs.--The recommended project is feasible from an engineering standpoint. The project improvements would provide substantial flood protection to (a) lands and improvements along Dreamy Draw and Cave Creek, including an intensively developed urban area of residential, commercial, public, and utility property, and (b) property subject to sheet flow in the lower Deer Valley area. The improvements would also supply flood protection to agricultural property along Skunk Creek, the New River, and the Agua Fria River and to urban property in the communities of Peoria and Avondale on the New and the Agua Fria Rivers, respectively. The improvements would also provide benefits from increased utilization of land for about 1,840 acres in the overflow area of Cave Creek. Construction of the improvements would permit the development of this land to its full potential by urban-type residential and commercial property.

12. The project plan is an integral part of the comprehensive flood-control plan for the Phoenix metropolitan area. The improved channels, particularly the channels in the New and the Agua Fria Rivers, would provide a major outlet for a local storm-drain system. The project improvements should meet foreseeable justifiable flood-control needs of that part of the Phoenix metropolitan area that is affected by Dreamy Draw, Cave Creek, Skunk Creek, the New and the Agua Fria Rivers, and the small washes between Cave Creek and the Agua Fria River.

13. If the Central Arizona project is authorized by Congress, the U.S. Bureau of Reclamation would construct an aqueduct across the drainage areas under consideration in this report. Consideration has been given to coordinating flood-protection works for that aqueduct with flood-control improvements under the comprehensive plan for the Phoenix metropolitan area.

14. Consideration was given to inclusion of fish, wildlife, and recreational facilities as part of the improvements recommended in this report. However, under present conditions, with water supplies limited to the natural flows of the streams under consideration, storage for water conservation or waterpower could not be justified. In addition, fish-and-wildlife or recreational facilities that could be developed would be minor and probably could not be justified because of the low average annual yield of the streams involved and the high evaporation and large infiltration losses that would occur in the reservoir areas. Under present conditions, recreational development at the detention basins probably would be limited to land-based recreation, such as day camping, picnicking, riding, and hiking. Such recreational facilities - if desired by local interests - would be so constructed, operated, and maintained by local interests as to be compatible with the project purpose. However, the Granite Reef aqueduct of the Central Arizona project, proposed by the Bureau of Reclamation, would cross the New River, Skunk Creek, and Cave Creek in the vicinity of the proposed detention basins. A definite location for this aqueduct has not been determined and all features of the Bureau project have not been firmed. With the importation of Colorado River water to the area, the proposed detention basins probably could be adapted for multiple-purpose use with mutual advantages for the Central Arizona project aqueduct facilities; for those future municipal water-supply treatment and distribution facilities of the city of Phoenix that would be supplied by the Central Arizona project; for the recreational plans of the Maricopa County Parks and Recreation Department; and for the fish-and-wildlife facilities to be developed jointly by the Arizona Game and Fish Department and the U.S. Bureau of Sport Fisheries and Wildlife. No detailed studies of fish-and-wildlife or recreational facilities were, therefore, made under present water-supply conditions. The addition of such facilities would not appreciably change the overall conclusions of the report.

Modification of the improvements recommended in this report would be made in the definite-project studies after the Central Arizona project plans are firmed, and upon determination of the economic justification of the additional facilities required. The recommended plan could also be modified to permit some floodflows to be delivered to existing canals downstream from the improvements or to water-spreading areas if local interests desire such facilities. The modification could be made at such time as desired by using agencies of local interests who would be willing to pay the added expense. All lands for construction of improvements under the recommended plan would be supplied by local interests. These lands would be administered by local interests in connection with their operation and maintenance of the project.

15. Allocation of costs.--The recommended plan would provide for a single-purpose flood-control improvement. No allocation of costs between purposes would be involved.

16. Local cooperation.--The terms of local cooperation for the recommended project would provide that, prior to construction, local interests would supply assurances satisfactory to the Secretary of the Army that they will (a) acquire and provide - without cost to the United States - all lands, easements, and rights-of-way necessary for the construction and subsequent maintenance and operation of the project; (b) perform - without cost to the United States - all necessary relocations of highways, roads, bridges, and utilities and all necessary street and highway modifications required in connection with construction of the flood-control works; (c) hold and save the United States free from any damages due to the construction works; (d) maintain and operate all the works, after completion, in accordance with regulations to be prescribed by the Secretary of the Army; (e) prevent any encroachment upon the improved channels or within the detention-basin areas that would reduce their flood-carrying capacity; and (f) hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the project. These terms are in accordance with provisions of flood-control law for local-protection projects.

17. Extent of interest in project.--Local interests desire protection from floods and prevention of resultant flood losses along Dreamy Draw, Cave Creek, and Skunk Creek; along the New and the Agua Fria Rivers; and along the small washes between Cave Creek and the Agua Fria River. The improvements they desire would also permit full development of certain lands within the overflow area and would eliminate interruptions to highway, irrigation, and utility services and to normal community activities. Local interests have given assurances of their cooperation in the project. Their interest in flood-prevention improvements in the area is indicated by the establishment of a flood-control district and by the

formulation and adoption of a comprehensive plan for flood control for the entire area. The Cave Creek Dam, upstream from the proposed Cave Buttes Dam, was built by local interests in March 1923 at a cost of $550,000. Local interests, to June 30, 1963, have expended an additional amount estimated at almost $9,000,000, principally in Phoenix and the adjacent area, for various flood-control works.

18. Other plans considered.--Local interests also requested consideration of a multiple-purpose dam providing for water-conservation and flood-control storage on the upper New River about 3 miles north of the settlement of New River. However, such a dam was not considered in detail because of the minor flood-control benefits that would accrue, as compared with the larger flood-control benefits that would accrue from a detention basin at a site farther downstream.

diversion channel, a length of about 3-1/2 miles. The design capacity would range from 100 cubic feet per second at the upstream end to 1,500 cubic feet per second at the downstream end. The channel, which would be excavated entirely below the natural ground, would have depths ranging from 7 to 9 feet. Bridges at Shea Boulevard, 16th Street, Winter Drive, 14th Street, Belmont Avenue, and 12th Street would be required.

(f) Arizona Canal diversion channel.--The Arizona Canal diversion channel, which would be just upstream from the Arizona Canal and nearly parallel to that canal, would extend from Dreamy Draw to Skunk Creek. The channel would comprise a 2-mile-long rectangular concrete section at the upstream end and a 10-mile-long trapezoidal earth section at the downstream end. The rectangular channel would have bottom widths ranging from 10 to 50 feet and depths ranging from 8 to 18 feet. The trapezoidal earth section would have bottom widths ranging from 20 to 220 feet and depths ranging from 8 to 20 feet. The design capacity of the channel would range from 1,500 to 18,500 cubic feet per second. Bridges would be required at 7th Street, Central Avenue, 7th Avenue, 19th Avenue, Black Canyon Highway, 43rd Avenue, 51st Avenue, 59th Avenue, and Northern Avenue.

(g) Adobe detention basin.--The Adobe detention basin would be constructed on an unnamed tributary of Skunk Creek, about 7 miles north of Bell Road and about 1 mile west of the Black Canyon Highway. The embankment would be a compacted-earthfill structure with a maximum height of about 76 feet above streambed. The crest of the dam would have a length of 3,850 feet. The detention basin, which would have a capacity of 19,400 acre-feet, would reduce a standard project flood with a peak inflow of 50,000 cubic feet per second to an outflow of 2,000 cubic feet per second. A diversion channel about 2-1/2 miles long would be excavated in earth to divert a standard project flood on Skunk Creek to the Adobe detention-basin area. Construction of the diversion channel would require construction of a bridge for the Black Canyon Highway.

(h) Skunk Creek channel.--The Skunk Creek channel would be a concrete-lined trapezoidal channel constructed along Skunk Creek from a point just upstream from the outlet of the Union Hills diversion channel downstream to a confluence with the New River, a distance of about 6-1/2 miles. The channel would have a design capacity ranging from 24,400 to 41,400 cubic feet per second, base widths ranging from 15 to 40 feet, and depths ranging from 10 to 23 feet. Bridges at 59th Avenue, Bell Road, and 83rd Avenue would be required; and about 2,000 feet of Union Hills Drive would be relocated.

(i) New River detention basin.--The New River detention basin would be constructed on the New River about 8 miles upstream from

the mouth of Skunk Creek. The main embankment would be a compacted-earthfill structure with a maximum height of about 80 feet above streambed. The crest of the embankment would be 2,700 feet long. An earthfill dike about 4,900 feet long would be required along the west edge of the detention-basin area. The detention basin, which would have a capacity of 39,500 acre-feet, would reduce a standard project flood with a peak inflow of 60,000 cubic feet per second to an outflow of 1,000 cubic feet per second.

(j) New River channel improvement.--The improved channel for the New River would extend from the mouth of Skunk Creek downstream to the confluence with the Agua Fria River, a distance of about 8 miles. The channel, which would be excavated in earth, would have revetted side slopes. The channel would be a trapezoidal section with bottom widths ranging from 400 to 800 feet and depths ranging from 8-1/2 to 11 feet. The design capacity of the channel would range from 53,400 cubic feet per second at the U.S. Highway No. 60 crossing of the channel to 58,000 cubic feet per second at the mouth of the New River. The Sante Fe railroad, the U.S. Highway No. 60, and the Glendale Avenue bridges would require modification. Dip crossings would be required at Thunderbird Road and at Peoria, Northern, and Olive Avenues.

(k) Agua Fria channel improvement.--An excavated earth channel would be constructed in the Agua Fria River for a distance of 7-1/2 miles from the mouth of the New River to a point about 2 miles downstream (south) of the bridge for U.S. Highway No. 80. The channel would be a trapezoidal section with base widths ranging from 800 to 1,500 feet and depths ranging from 8-1/2 to 10 feet. The design capacity of the channel would range from 70,000 to 74,000 cubic feet per second. About 1/2 mile of El Mirage Road would be relocated. Dip crossings would be provided for Van Buren Street and for Indian School, Thomas, and McDowell Roads.

6. Each of the detention basins would be designed to control a standard project flood from the drainage area upstream from the dam. Each of the diversion channels and the other channel improvements would be designed to control the runoff estimated to occur on an average of about once in 100 years. Floods of these magnitudes, although only about 46 percent of the standard project flood, are larger than any known flood of record in the metropolitan area. The capacities of the recommended channels would be considerably more than the nondamaging capacities of the existing washes. Improvements under the recommended plan would prevent about 89 percent of the total average annual damages in the overflow areas along Dreamy Draw, Cave Creek, and Skunk Creek; along the New and the Agua Fria Rivers; and along the small washes between Cave Creek and the Agua Fria River. Most residual damages would result from flows originating downstream from the proposed works. The economic life of each project unit is considered to be 100 years.

7. Project costs.--The estimated first costs for the recommended project, based on October 1963 prices, are given in the following table:

Estimated first costs of recommended project - Phoenix, Ariz., and vicinity (including New River)

Item	Estimated first costs
Federal (construction of channels and detention basins)	$59,680,000
Non-Federal (rights-of-way and relocations)	11,120,000
Total	70,800,000

8. The average annual cost (all non-Federal) for maintenance and operation is estimated at $223,000 Preauthorization costs of $275,000 already expended are not included in the preceding estimates.

9. Benefit-cost ratio.--Average annual costs and benefits and benefit-cost ratios for the recommended project, developed on the basis of an economic life of 50 years and an economic life of 100 years, are given in the following table. An interest rate of 3 percent was applied, and October 1963 prices were used.

Pertinent information on average annual costs and benefits and benefit-cost ratios for recommended project - Phoenix, Ariz., and vicinity (including New River)

Item	Life of project	
	100 years	50 years
Average annual costs:		
Interest and amortization (Federal)	$1,927,000	$2,367,000
Interest and amortization (non-Federal)	581,000	665,000
Maintenance and operation (non-Federal)	228,000	228,000
Total	2,736,000	3,260,000
(Say)	2,740,000	3,260,000

Pertinent information on average annual costs and benefits and benefit-cost ratios for recommended project - Phoenix, Ariz., and vicinity (including New River)--Continued

Item	Life of project	
	100 years	50 years
Average annual benefits:		
Prevention of flood damages	$7,750,000	$5,830,000
Increased utilization of land	460,000	420,000
Total	8,210,000	6,250,000
Ratio of benefits to costs	3.0 to 1	1.9 to 1

10. Intangible project effects.--Many benefits not susceptible of monetary evaluation would accrue from the operation of the improvements considered in this report. Such benefits would include reduction of the danger of loss of life from floods. Loss of life has occurred in the Phoenix area in previous floods; with the rapidly increasing development in the overflow area, the danger of loss of life is increasing. Other intangible benefits would result from (a) prevention of such interruption of services from the Arizona Canal as would occur when the canal is emptied to perform flood-control diversion during rainstorms or is breeched by floodflows; (b) reduction of epidemics caused by flood damages to sewer and water systems; (c) prevention of interruptions to traffic, business transactions, public utilities, home life, and school and other normal community activities; and (d) preservation of community morale by reducing the fear of floods in the overflow areas.

11. Current and future needs.--The recommended project is feasible from an engineering standpoint. The project improvements would provide substantial flood protection to (a) lands and improvements along Dreamy Draw and Cave Creek, including an intensively developed urban area of residential, commercial, public, and utility property, and (b) property subject to sheet flow in the lower Deer Valley area. The improvements would also supply flood protection to agricultural property along Skunk Creek, the New River, and the Agua Fria River and to urban property in the communities of Peoria and Avondale on the New and the Agua Fria Rivers, respectively. The improvements would also provide benefits from increased utilization of land for about 1,840 acres in the overflow area of Cave Creek. Construction of the improvements would permit the development of this land to its full potential by urban-type residential and commercial property.

12. The project plan is an integral part of the comprehensive flood-control plan for the Phoenix metropolitan area. The improved channels, particularly the channels in the New and the Agua Fria Rivers, would provide a major outlet for a local storm-drain system. The project improvements should meet foreseeable justifiable flood-control needs of that part of the Phoenix metropolitan area that is affected by Dreamy Draw, Cave Creek, Skunk Creek, the New and the Agua Fria Rivers, and the small washes between Cave Creek and the Agua Fria River.

13. If the Central Arizona project is authorized by Congress, the U.S. Bureau of Reclamation would construct an aqueduct across the drainage areas under consideration in this report. Consideration has been given to coordinating flood-protection works for that aqueduct with flood-control improvements under the comprehensive plan for the Phoenix metropolitan area.

14. Consideration was given to inclusion of fish, wildlife, and recreational facilities as part of the improvements recommended in this report. However, under present conditions, with water supplies limited to the natural flows of the streams under consideration, storage for water conservation or waterpower could not be justified. In addition, fish-and-wildlife or recreational facilities that could be developed would be minor and probably could not be justified because of the low average annual yield of the streams involved and the high evaporation and large infiltration losses that would occur in the reservoir areas. Under present conditions, recreational development at the detention basins probably would be limited to land-based recreation, such as day camping, picnicking, riding, and hiking. Such recreational facilities - if desired by local interests - would be so constructed, operated, and maintained by local interests as to be compatible with the project purpose. However, the Granite Reef aqueduct of the Central Arizona project, proposed by the Bureau of Reclamation, would cross the New River, Skunk Creek, and Cave Creek in the vicinity of the proposed detention basins. A definite location for this aqueduct has not been determined and all features of the Bureau project have not been firmed. With the importation of Colorado River water to the area, the proposed detention basins probably could be adapted for multiple-purpose use with mutual advantages for the Central Arizona project aqueduct facilities; for those future municipal water-supply treatment and distribution facilities of the city of Phoenix that would be supplied by the Central Arizona project; for the recreational plans of the Maricopa County Parks and Recreation Department; and for the fish-and-wildlife facilities to be developed jointly by the Arizona Game and Fish Department and the U.S. Bureau of Sport Fisheries and Wildlife. No detailed studies of fish-and-wildlife or recreational facilities were, therefore, made under present water-supply conditions. The addition of such facilities would not appreciably change the overall conclusions of the report.

Modification of the improvements recommended in this report would be made in the definite-project studies after the Central Arizona project plans are firmed, and upon determination of the economic justification of the additional facilities required. The recommended plan could also be modified to permit some floodflows to be delivered to existing canals downstream from the improvements or to water-spreading areas if local interests desire such facilities. The modification could be made at such time as desired by using agencies of local interests who would be willing to pay the added expense. All lands for construction of improvements under the recommended plan would be supplied by local interests. These lands would be administered by local interests in connection with their operation and maintenance of the project.

15. Allocation of costs.--The recommended plan would provide for a single-purpose flood-control improvement. No allocation of costs between purposes would be involved.

16. Local cooperation.--The terms of local cooperation for the recommended project would provide that, prior to construction, local interests would supply assurances satisfactory to the Secretary of the Army that they will (a) acquire and provide - without cost to the United States - all lands, easements, and rights-of-way necessary for the construction and subsequent maintenance and operation of the project; (b) perform - without cost to the United States - all necessary relocations of highways, roads, bridges, and utilities and all necessary street and highway modifications required in connection with construction of the flood-control works; (c) hold and save the United States free from any damages due to the construction works; (d) maintain and operate all the works, after completion, in accordance with regulations to be prescribed by the Secretary of the Army; (e) prevent any encroachment upon the improved channels or within the detention-basin areas that would reduce their flood-carrying capacity; and (f) hold and save the United States free from all damages arising from water-rights claims resulting from construction, maintenance, and operation of the project. These terms are in accordance with provisions of flood-control law for local-protection projects.

17. Extent of interest in project.--Local interests desire protection from floods and prevention of resultant flood losses along Dreamy Draw, Cave Creek, and Skunk Creek; along the New and the Agua Fria Rivers; and along the small washes between Cave Creek and the Agua Fria River. The improvements they desire would also permit full development of certain lands within the overflow area and would eliminate interruptions to highway, irrigation, and utility services and to normal community activities. Local interests have given assurances of their cooperation in the project. Their interest in flood-prevention improvements in the area is indicated by the establishment of a flood-control district and by the

formulation and adoption of a comprehensive plan for flood control for the entire area. The Cave Creek Dam, upstream from the proposed Cave Buttes Dam, was built by local interests in March 1923 at a cost of $550,000. Local interests, to June 30, 1963, have expended an additional amount estimated at almost $9,000,000, principally in Phoenix and the adjacent area, for various flood-control works.

18. Other plans considered.--Local interests also requested consideration of a multiple-purpose dam providing for water-conservation and flood-control storage on the upper New River about 3 miles north of the settlement of New River. However, such a dam was not considered in detail because of the minor flood-control benefits that would accrue, as compared with the larger flood-control benefits that would accrue from a detention basin at a site farther downstream.